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Cost Finding

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PREFACE

THE aim of this Text is to discuss in a direct and simple manner the fundamental principles that underlie all cost-finding systems. Abstruse and abstract arguments have been avoided and an effort has been made to make the work of practical use. Commercial data, diagrams and typical documents used in cost finding have been inserted only where needed to illustrate the discussion, and no attempt has been made to present complete cost systems, as is often done in treatises of this kind. Industrial conditions vary widely, and it is believed that if the fundamental principles of cost finding are thoroly understood and the peculiar conditions of the particular problem in hand are carefully studied, the making of blanks and forms should be a minor difficulty.

Care has been taken, also, to point out as far as possible the limitations of the theories and methods that have been discussed. Cost finding, at best, is a complex matter and is far from being an accurate science. The successful choice of a cost-finding system that will be suitable for a given set of conditions depends to a large degree on a knowledge of the limitations of the methods to be employed. In all prob-

ability more systems fail because of lack of knowledge of limitations on the part of those instituting or operating such systems, than for any other single reason.

In the preparation of this volume the works of other writers in this field have been consulted, and so far as possible such aid has been acknowledged in the Text. Grateful acknowledgment is made, however, for such help as has not been specifically mentioned. Special acknowledgment is made to Mr. A. Hamilton Church and Mr. Sterling Bunnell from whose writings much helpful assistance has been drawn. Any suggestions or criticisms that will assist in improving the Text will be gratefully received.

DEXTER S. KIMBALL.

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COST FINDING

CHAPTER I

THE IMPORTANCE OF COST FINDING

1. *Few men understand cost finding.*—As a part of modern industrial organization the importance of cost accounting can hardly be overestimated. At the same time there is perhaps no part regarding which so little is generally known. In the great majority of industrial establishments the art of cost finding is still in a crude and undeveloped stage, so far at least as individual detail costs are concerned. This is particularly true of the small shop, or the shop which has grown up around a pushing and skilled mechanic, whose knowledge of the practical side of his art is great, but who neither knows nor appreciates the need of scanning his detail costs more closely as his business becomes more and more complex. According to *Bradstreet's,* four-fifths of the industrial failures in this country are the result of faults, or incompetence of one kind or another, on the part of those who fail, and ignorance of the true cost of production is, without doubt, one of the most common of the shortcomings.

2. *Purpose of cost records.*—Cost finding is a complex matter at best, and as industries grow to great proportions this complexity is increased in like ratio. The methods and approximations which may be adequate for a small business which is wholly under the eye of the superintendent, can not be relied upon when the plant becomes so large that personal observation is insufficient; system of some sort must be resorted to. Furthermore, the demands of modern industry require vastly more of a cost system than was deemed necessary a short time ago. In many shops, today, the cost system is considered satisfactory if it simply shows the cost of producing the several items manufactured. But the modern conception of a cost-finding system is far broader. Such a system must not only show costs as such, but must show them in such a form that deductions may be drawn as to the reasons for them and the possibilities of reducing them. Results must be so reliable that the costs may be used as a basis for predicting future shop operations and costs. A cost-keeping system that simply records costs for the purpose of fixing sales prices has accomplished only a small part of its mission, and every day shows an increasing tendency to demand of the cost department that it furnish each activity of the enterprise such statistical statements as will act as safeguards in the conduct of its individual functions.

A good cost system properly conducted should enable the manager to prepare estimates with some assurance that a profit will be made if the work is

undertaken, and at the same time should enable him to meet competition on an intelligent basis. It should tell him what lines of product pay and what do not. It should enable him to gauge the efficiency of each department and to trace the reasons for inefficiency if such exists. It should be his guide and counselor in directing the activities of his business. On the other hand, care must be exercised that the system installed is not too complex and that the cost of securing the detailed information is not greater than the gain that may result from its possession. Complexity is no assurance of accuracy. And an over-complex system may not only secure results that are useless but may be an actual hindrance to rapid production, thru too much "red tape."

3. *Trained men required.*—As will be seen later, there is almost no end to the detail to which a cost-finding system may be carried. In the hands of an overzealous accountant or one whose range of vision is narrowed by the intricacies of his calling, an over-elaborate system may be installed that not only will result in financial loss, thru the expense of operating the cost-finding machinery, but also, as has been noted, may act as a clog on the actual machinery of production. The introduction of a satisfactory cost system requires, therefore, more than a knowledge of cost-finding methods. It requires an intimate knowledge of the industry itself, of the particular institution, and a keen discrimination regarding the detail to which the cost finding is to be carried. Very rough

detail costs may be satisfactory in some lines while very refined cost statements may be essential in others. Even in the same establishment the same degree of detail accuracy is not necessary in all lines, and a skilled cost accountant can save large sums in the operation of his system by a careful observance of the relative importance of different lines of product.

For these reasons the installation of a cost-finding system should not, usually, be left wholly to the general accountant. It is true, of course, that the cost books, for best results, should be properly merged into the general accounts and should fit into the broad plan of a general scheme of accounting. But the cost-finding methods that will produce best results will, in general, be the result of the joint labors of the skilled accountant and the manufacturing expert. A careful distinction should be made between principles and the detail to which the application of these principles may be carried. The principles of cost accounting are definite and permanent, but the degree of detail to which it is desirable to carry their application can be fixed only by some one well versed in the details of manufacturing, who knows just what results are desirable and what results are useless.

Even the manufacturing expert and the skilled accountant can obtain much help by considering the requirements of other departments. Thus the clerical work and accuracy of cost finding are greatly aided by a proper system of nomenclature and identification. Such matters involve the work of the designing

department, and a system in the drafting room laid out with reference to the cost-finding system is an invaluable aid.

4. *Each business requires individual study.*—It is obvious also that no particular cost-finding system will apply to all forms of industry, since industries vary so widely not only as regards the character of the work they are conducting but also as regards the manner of their organization. The information that the cost system should gather, and the manner in which this information should be presented, will also vary widely in different enterprises. The cards and forms which are admirable for one kind of work are useless, therefore, in others. The general underlying principles of cost finding are, however, universally applicable and if the principles are clearly understood there is seldom any difficulty in developing cards and forms suitable to the work in hand. Many good suggestions can be obtained by a study of the blanks and forms found in current practice, but the presentation of too great a variety of such documents tends to obscure basic theory. This book, therefore, deals with general principles only, and only such blanks and forms have been inserted as are necessary to illustrate these principles.

5. *Importance to whole industries.*—While accurate costs are of great importance to the individual institution, they are of no less importance to the industry as a whole. The manufacturer who obtains contracts by underbidding his competitors, with a price on which

he will lose money, not only ruins his own business but destroys that of his competitors. This form of competition is the most dangerous and the most greatly to be feared, since it rests, in most cases, on ignorance. It is little consolation to the manager whose costs are accurately obtained to see such competitors go into bankruptcy; for, as fast as they disappear, others equally ignorant take their place. This state of affairs is far too common.

In a competition that came under the writer's observation recently, the highest bid was nearly fifty per cent higher than the lowest. After making allowance that the lowest bid may contemplate scant fulfilment of the specifications, and that the highest may be simply hopeful advertising, the only reasonable explanation that can be offered for such a great range is ignorance of basic cost-finding principles. Any one who has had experience in opening competitive bids will testify to the wide divergence in prices that usually appears in such competition. It is for reasons such as these that the intelligent manufacturer often finds himself confronted with the fact that his bid must be based on market prices and not on his costs. It is no use to bid higher, unless he has a superior article the merit of which commands the trade irrespective of price. On standard articles the "trade will not stand" the higher price. Even here his only hope of succeeding is to know the true cost and to try, by better manufacturing, so to reduce it as to leave him a margin of profit.

Furthermore, it is only too often held that cost-finding methods are secret matters that should be kept from the eyes of competitors. No doubt it may be good business policy to keep actual costs secret, but the widest publicity should be given to cost-finding methods if for no other reason that that of educating one's competitor in such methods as shall tend to fair competition. This is now clearly recognized in many fields of industry. The National Machine Tool Builders' Association recognized this important principle some years ago and took active steps toward uniform methods. It would pay all competing industries to do likewise and to publish freely the correct methods by which the costs of their products are obtained. The manager who offered to send his expert accountant, at his own expense, to teach competitors his system of cost finding was a man of keen business ability and not simply a philanthropist.

6. *Inadequacy of crude methods.*—It is true, of course, that many enterprises make money with the crudest kind of cost-keeping systems, but where such is the case there are always advantageous conditions the continued existence of which cannot elsewhere be assumed. Many plants, also, make money in spite of antiquated machinery and methods, either because of local advantages or because lack of competition allows large profits. Strong leadership may often compensate for material disadvantages. But such favoring conditions may not be easy to maintain in the future. As industry grows, competition becomes ever keener

in all branches of life, with the consequent requirement of a more exact knowledge of the details of business. And as any enterprise increases in size the methods based merely on personal observation become increasingly inadequate.

A grocer who fixed the selling price of sugar with reference to that of his competitor, and not with reference to what it had cost him, would be considered as having adopted a decidedly unsafe policy. And yet this is a common method of fixing prices in the manufacturing field. Many manufacturers are unwittingly paying dividends out of capital simply because they do not know what their selling price ought to be but have fixed it either by that of some competitor or by some rule of thumb. Enterprises of this kind collapse like houses of cards when dull times arrive, and constitute, no doubt, a large proportion of the failures which are due to personal incompetence. Accurate knowledge of the cost of production is an absolute necessity, and the detail in which it is required to know these costs grows daily with the growth of enterprises, the increase in competition and the development of new methods of management.

7. *Cost finding and profits.*—Nothing that has been said or that will be discussed later in this Text must be construed to mean that profits will simply amass themselves wherever a cost-finding system is installed. What really determines profits is the economic principle of supply and demand, and not the manufacturer's cost of production. In a cycle of prosperity

when everything is booming, loose methods of manufacturing and cost accounting, or no cost accounting at all, might and sometimes do prevail and profits result. With increasing competition and reduced prices weaker companies are forced out, or, lacking exact knowledge of manufacturing costs, they will keep on reducing prices to meet competition until their capital is eaten away. Without exact costs no manufacturer can tell whether or not one seemingly unimportant article is carrying the rest of his business on its profits.

If the price that the public is willing to pay will not warrant the manufacturing cost entailed, it is unwise to proceed with manufacturing. Demand at such a price will be met only by improvident manufacturers who do not know what their costs are. When they have been forced out of business prices will rise and other manufacturers will enter the field again.

REVIEW

What reasons would influence you to establish a cost-finding system in your own business?

What effect upon your decision would the following factors have: size and character of the business; expense of installation and operation?

If the selling prices of the product that you are manufacturing are regulated primarily by competition, would you consider it advisable to install a cost system? Why?

What benefits would you, as a manufacturer, derive from the adoption of a uniform system of cost finding in the industry, and would they lead you to cooperate freely in the plan?

NOTE: The review questions thruout this volume are solely for the personal convenience of the reader in testing his understanding of the chapter.

CHAPTER II

PROBLEMS OF COST FINDING

1. *Bookkeeping, accounting and cost finding.*—A clear conception should be had of the relation between accounting, bookkeeping and cost finding. Accounting is the science of recording transactions in terms of money, which is the measure of all commercial and productive performances. Where properly conceived it is of much wider scope than bookkeeping, with which it is often considered identical. Bookkeeping is, more strictly speaking, the clerical work of recording transactions, but accounting goes further and deduces financial statements that may serve as safe guides for the conduct of the business. Almost any one can introduce a system of bookkeeping that will show the balances and general results of the business, but to lay out an accounting system that will anticipate future performances and guide the manager safely where the details are so great as to be beyond his grasp, is a different matter.

Cost finding is that part of general accounting which deals with the finding of the detail costs which make up the general or summarized costs. It is, therefore, closely connected with shop processes and shop management, and the cost keeper usually is

placed directly under the manufacturing superintendent. Cost finding can be carried on with little reference to the general accounts, and this practice is not uncommon. The general books should always show accurately the totals of all labor and material that have been purchased for any and all purposes, and also all receipts for sales, without regard to the details as to how these expenditures and receipts were brought about. It is clear also that these totals, as shown by the general accounts, can be accurately determined, since they are based upon purchase orders, pay-rolls, bills of sale and similar documents. It is clear, also, that these general summaries will show whether the business is prospering or not and will show also whether the prices asked are, in general, sufficiently high to cover all expenditures and insure a profit. However, if it is desired to know something regarding the detailed cost of some particular job or article this information can be obtained only by opening a special ledger account with it. In small enterprises this is sometimes done, but in undertakings of any magnitude such a procedure would lead to undesirable complexity and extent in the general accounts. Cost accounts are therefore usually conducted as an independent investigation, the cost summaries not necessarily being merged into the general accounts.

2. *Cost accounts a branch of general accounts.*—For best results, however, the cost accounts should be treated as a branch of the general accounts, and the

cost summaries should be merged into the general accounts. It will be seen from the following discussion that it is difficult to keep absolutely accurate cost accounts, and that the cost summaries do not always agree with the corresponding totals of the general accounts. These facts are sometimes used as arguments against cost-finding systems as a means of setting sales prices, but such arguments are not valid. Any cost-finding system worth considering should give results that can be reconciled with the totals of the general accounts with sufficient accuracy, or the difference should be explainable on some other ground than that of inaccuracies in the cost-finding methods. General accounting is obviously necessary to secure accurate general summaries, and cost accounts are necessary to show the details of each summary where such details are needed. The two systems should, therefore, be related parts of one general scheme of accounting. Evidently the installation of a cost-finding system should be the joint work of the skilled accountant and the manufacturing expert.

General accounting must be conducted in practically every business, but cost finding, in a detailed sense, may or may not be necessary, tho, as before stated, it is often badly needed in many places where it is not considered necessary.

3. *Divisions of productive industry.*—To illustrate these relations, consider the case of a farmer who is producing wheat, barley, oats, cattle, sheep, poultry, eggs and, in addition, operates a small truck garden

where he grows a number of varieties of vegetables. Under the old methods which were practised a few years ago, his farm and the labors of his family and himself would perhaps supply him with practically every need. Accounting was hardly needed, since he could see the state of his resources. But under present conditions he must buy many of his necessities; if he hires helpers they must be paid in money, which can be obtained only by selling the products of his farm. He must, therefore, add to his labors as a producer both those of a buyer and those of a seller. It now becomes increasingly difficult for him to carry the records of his many transactions in his head, and he must proceed to write them down in some orderly and systematic manner, thus adding accounting to his required duties. The growth of the farmer's activities also brings about added financial responsibilities to which special attention must be devoted. Thus, he may be compelled periodically to borrow money in order to harvest his crop promptly or to perform a large amount of plowing in a short time. The essential features of productive industry, in short, are buying, producing, financing, transporting to market, selling and accounting. In most cases buying is considered as a part of producing, and transportation to market as a part of selling, so the four divisions of production are manufacturing or growing, financing, selling and accounting.

If, now, this farmer is prosperous, he may keep only such accounts as deal with his receipts and dis-

bursements. He will record all purchases for fertilizer, machinery, insurance, repairs, drain tile, etc., and will also record all money received from sales of produce. The balances from these general accounts will always inform him how he stands, as a whole, with his business world.

4. *When cost records become necessary.*—But suppose he is not prospering, or suppose he wishes to know what lines of effort are giving him his highest returns. He then must begin to keep an individual account with each activity into which he wishes to inquire. Many farmers of the better informed class now keep records of each cow or even of each hen in making economic studies of this kind. Almost instantly, however, the farmer under discussion finds that these individual cost accounts are decidedly different in character from the general accounts he has been keeping. The general accounts were accurate and he could account fully for all the items entering therein. But these individual accounts contain items that are not definite.

For instance, the same man that feeds the cattle helps to market the eggs. The insurance on the barn is chargeable partly to one activity and partly to another. Some of the general supplies which he has purchased spoil on his hands; other supplies are not fully accounted for, because of waste, or failure to obtain accurate account of their distribution. Some of the supplies that he has purchased are used in so many different activities that he finds it difficult to

apportion them with any semblance of accuracy. He also finds it practically impossible to apportion accurately his labors in his truck garden over the many products grown therein. He must, therefore, be content with approximation to a certain extent in making up these accounts. The greater the detail into which he wishes to go the more difficult it becomes to segregate the costs of the several lines of effort with which he is concerned. It is clear, however, that by making intelligent approximations he can separate the cost of his several activities so as to obtain a fairly clear view of their relative values, and if these approximations are skilfully made the summaries of his cost accounts should coincide fairly well with those of his general accounts. This particular difference between general accounts and cost accounts should be carefully noted. The general accounts must be accurate and must balance; cost accounts are seldom exact and it is often difficult to make their summarized totals agree closely with those of corresponding general accounts which are based on much more accurate statements.

If this farmer is very progressive or has a speculative mind, he may record the relative costs of producing different products under varying conditions, with a view to guiding himself in future work. That is to say, he begins to collect statistical data based on his cost accounting which will enable him to predict, in some degree at least, the results of future efforts. This was once a secondary feature of cost accounting, but it now bids fair to be as important as the original

function performed by cost-finding methods, namely, that of finding out what the actual costs of production are.

The general principles underlying the farmer's cost records are applicable to all branches of productive industry tho the methods of applying them may vary widely. The illustration of the farmer was purposely selected to show that these principles apply even to handicraft production of the simplest kind. A brief consideration of any of the handicraft callings, particularly as they grow in magnitude, will disclose analogous conditions, and will assist in making clearer the increasing complexity of these principles as they appear in large modern factories. It is in the highly organized modern factory that the greatest complexity is met; the following discussion is therefore directed largely to factory methods. The general application, however, should not be lost sight of.

5. *Application to manufacturing plants.*—One of the most marked and important characteristics of modern industry is the tremendously extended use of the principle of division of labor. While this principle is inherent in the formation of civilized society and has been used by mankind from the beginning, the modern industrial era has extended its use in a most remarkable degree. The installation of highly developed and specialized machinery has aided materially in furthering the use of this principle. The production of the smallest article may be the work of many hands. One man may plan or design it, another may

make tools for its production, many others may work on individual operations, not even knowing what sort of article the several parts are intended for; while others, who may not have seen a single part manufactured, may assemble the completed product. The cost of any manufactured article, therefore, may be made up of the cost of small portions of labor of many men, some of whom may work directly upon the article and some of whom may work only indirectly upon it. As in the case of the farmer, it may not be easy to compute just what the exact total cost of the final product may be.

A diagrammatic outline of the essential factors in any productive enterprise is shown in Figure 1 (page 18). No matter how complex the ownership of a plant may be, it can be, and usually is, reduced to a board of directors or some similar group which represents the owning body, and dictates the general policy of the enterprise. These directors in turn may be represented by the president or general manager who is in actual charge of the plant. They may also elect such officers as the secretary and the treasurer to serve as independent checks on the operation of the business. Under the president are the four main branches or departments of operation already noted, namely, producing, selling, financing and accounting. If the plant is owned by partners or by an individual the organization is, of course, simplified, and where the plant is small, one individual may perform several of the foregoing functions. The general idea, how-

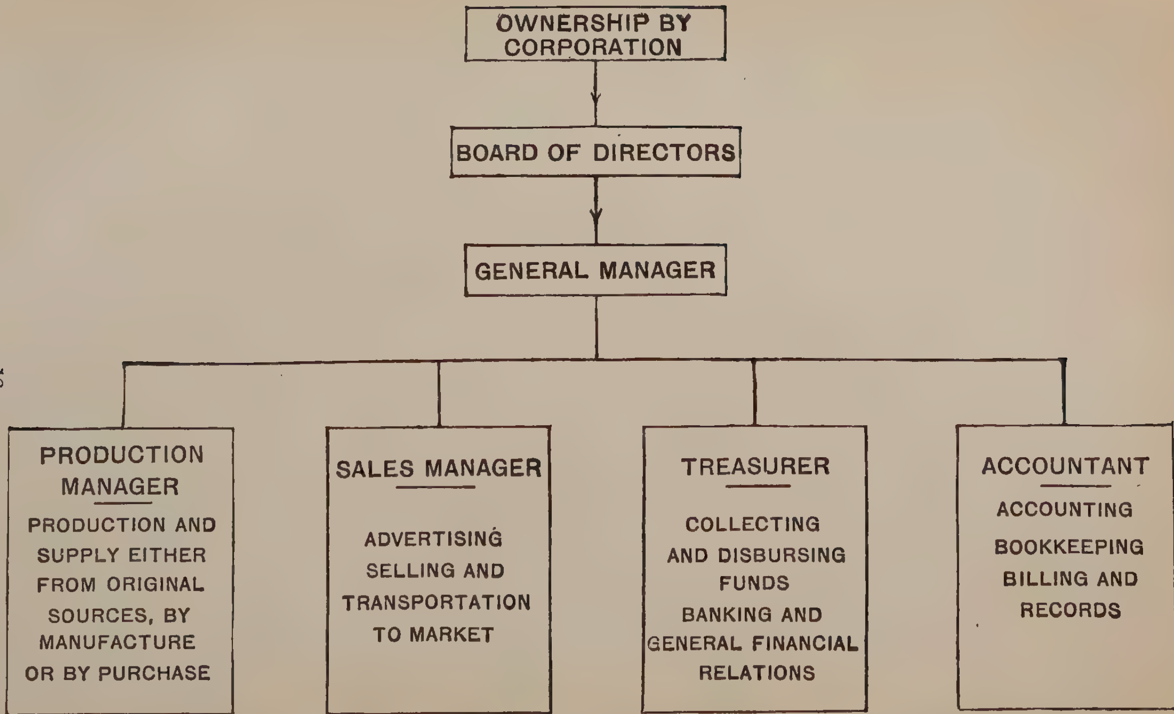


Figure 1. The Four Fundamental Branches of an Enterprise

ever, of the four main branches should not be lost sight of, no matter how much the detail arrangements of the administration may vary. For instance, in some cases the engineering department is so important as to be placed directly under the general manager, but this is purely an administrative matter and does not affect the principles presented, the engineering department being strictly a branch of the production department. Such an arrangement is, in fact, another manifestation of the advantage of division of labor. Formerly all engineering planning was done in the shop as the work progressed, and often by haphazard methods. Experience has shown that better and more economical results are obtained when this work of planning is in the hands of specialists. Similar remarks would apply to industries where other kinds of highly trained specialists, such as chemists, for example, are employed.

6. *Departments not always fully developed.*—It may be noted that the degree to which some of these departments may be developed in any one industry or enterprise may vary widely with conditions. Some concerns have only very rudimentary sales departments, depending on other organizations to dispose of their product. In other cases the sales organization may be highly developed and it is not uncommon that the cost of marketing a commodity is equal to, or greater than, the actual cost of production. Other enterprises, again, may do little or no purchasing of materials except for machinery and repairs, having

acquired once for all such natural sources of supply as are necessary for their purpose. Still other enterprises do no producing, in a strict sense, the purchasing department taking the place of the production department which is so prominent a feature of other industries. Thus a mercantile concern simply buys finished or marketable goods and sells them again. The general principles involving all four functions should not be forgotten, however, and accounting, as has already been noted, must always be carried on, whether the enterprise in question does buying, producing, or selling, or all three combined.

7. *Departmentization.*—As a factory grows in size, or as the scope of the work broadens, the economic advantage of the use of division of labor naturally brings about departmentization. Departmentization is also desirable from the standpoint of administration—and the entire problem of cost finding is closely connected with the problems of organization. A diagrammatic outline of the several departments of a typical manufacturing enterprise, showing the relative positions of the several departments from an administrative standpoint, is shown in Figure 2 (page 21). The four main divisions, producing, selling, financing and accounting, are functionalized under the general manager, in the care of the sales manager, the factory manager, the treasurer and the accountant or controller. Under the factory manager is organized the production department with its many sub-departments. Some of these sub-

departments are functionalized directly under the factory manager while others are placed under the factory superintendent. The arrangement shown is suggestive only, tho it illustrates a somewhat common arrangement of the several departments.

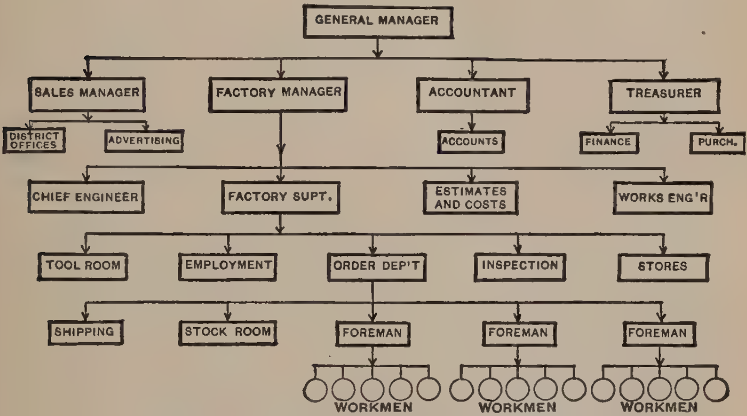


FIG. 2 DIAGRAM OF A MANUFACTURING ORGANIZATION

It will be noted that the duties and functions of the men in the various departments are often decidedly different in character. Thus, there is little in common between the work of the shipping room and that of the labor bureau. It will be noted also that many of the men employed do not work directly upon the product. The engineer in charge of the power house, for example, does no work on the product itself and the power which his department produces may or may not be used on all products. The engineering depart-

ment may make designs for some jobs,[1] while for others it may do nothing. Crane men, office clerks, errand boys, etc., are employed on work that is general rather than specific, and it is difficult to apportion accurately the amount of time that they spend on each piece of the factory product. The proportion of men that may be thus indirectly employed may be very large, and the modern tendency in all mass production is to increase this proportion rather than to diminish it.

This general tendency toward departmentization and division of labor should be carefully noted by the student of cost systems. Certain fundamental principles in modern manufacturing methods work irresistibly to increase this tendency. The four primary divisions of a business, namely producing, selling, financing and accounting, are functional divisions. That is, the division is based on the *character* of the work performed. Again, under the factory manager (see Figure 2) are found several departments, the functions of which are different. The designing of the product is separated from the actual construction, and the estimating is set aside as the separate function of a specialist. The separation of the planning of the work from its construction should be especially noted. Until quite recently this principle had not gone far beyond the separation of the engineering and the construction department. But recent develop-

[1] The author feels that no apology is needed for the use of this homely but expressive term. There is no other word that fully takes its place.

ments tend to carry this principle of the separation of the planning and the constructive function much farther down into the shop itself. Scientific management, so called, is based intrinsically on a rearrangement of the work of foremen and workmen according to the *functions* to be performed, rather than according to the principles underlying the enforcement of discipline, as heretofore. Functional foremanship, as contemplated by scientific management, has become an important factor in our present day industrial organization, and the tendency toward further specialization of this order seems to be growing. Such a separation of functions always increases the amount of general, or indirect, labor and decreases the amount of specific, or direct, labor that is put upon the product. As the tendency grows, the necessity of more accurate distribution of cost increases while, at the same time, the difficulties in the way of accurate allocation of cost elements also become greater; all of which points to the need for more refined cost-finding methods as competition becomes keener.

REVIEW

Differentiate bookkeeping, accounting and cost finding.

In your opinion is it advisable to provide for a control of the cost books by means of accounts in the general books?

How would you prepare for your own use charts that will show:

(a) the four fundamental branches of a business enterprise?

(b) the diagrammatic outline of a manufacturing business?

Upon what fundamental idea is scientific management based, and what are some of its features?

CHAPTER III

PROBLEMS OF COST FINDING (*Continued*)

1. *Basic cost problem similar in all industries.*—It will be noted, therefore, that the problem of cost finding in the factory is little different from that of the farmer previously discussed. The difference is one of degree rather than one of principle. Competition has, however, compelled the factory owner, in general, to look more closely into his costs; the agriculturist may in the future be compelled by the same economic pressure to do likewise.

Industrial enterprises, of course, vary widely, not only in the character of the work they pursue but also in the way in which they are organized and departmentized. Furthermore, as will be shown, no single cost-finding system can be devised that will be suitable for all enterprises. The importance of understanding correct basic principles is therefore apparent.

2. *Other relations to general accounting.*—The problem of cost finding will be more clearly understood, also, by considering certain other characteristics of the manufacturing industry. As before noted, the general accounts indicate the general condition of the business and should also, if properly conducted, indicate the general tendencies of the business. Figure

3 (page 26) shows a typical monthly statement of the affairs of a manufacturing company. In it the condition of the assets and liabilities of the company under consideration have been summarized. Among the "fixed" or "permanent" assets are found such items as buildings, machinery and tools, drawings and patterns, shop furniture and fixtures. These assets are not permanent, however, in the sense that their value does not change. As a matter of fact, they are constantly being added to and are constantly depreciating in value either from use or from decay. Much of the labor expended in the construction and repair of these utilities is the work of men regularly employed, and much or all of the material used passes thru the regular channels of purchase and storage. Some of these expenditures of labor and material, however, are expenditures on the capital account and add to the value of the assets. It is important that the value of these expenditures be known as closely as possible, and hence they must not be confused with those connected with the manufacture of product for the market. Cost finding, therefore, is concerned with, and must take account of, many other things besides production for the market.

Again, on the monthly statement are found the values of raw materials, work in process, and finished product; that is, the value of all raw or unworked material, the value of all material passing thru the shop and partly worked into finished product, and the value of all material fully completed and

MONTHLY STATEMENT, BROWN MFG. CO.												
	MARCH 31, 19—						APRIL 30, 19—					
	DR.			CR.			DR.			CR.		
FIXED ASSETS												
REAL ESTATE	60	500	00									
BUILDINGS	200	225	00									
MACHINERY AND TOOLS	150	345	00									
FACTORY FURNITURE	7	240	00									
OFFICE FURNITURE	2	100	00									
DRAWINGS AND PATTERNS		100	00									
TOTAL	420	510	00									
CURRENT ASSETS												
CASH	7	241	52									
STOCKS AND BONDS	2	500	00									
NOTES RECEIVABLE	1	250	50									
ACCOUNTS RECEIVABLE	75	240	30									
RAW MATERIALS	40	264	18									
MATERIAL IN PROCESS	50	146	15									
FINISHED PRODUCT	20	240	24									
GOODS ON CONSIGNMENT OUTWARD	5	140	10									
SUPPLIES	1	240	00									
TOTAL	203	262	99									
FIXED LIABILITIES												
FUNDED DEBTS												
MORTGAGE BONDS				10	000	00						
MORTGAGES				5	000	00						
TOTAL				15	000	00						
CURRENT LIABILITIES												
NOTES PAYABLE				35	000	00						
ACCOUNTS PAYABLE				52	246	15						
PAYROLL				3	218	16						
TAXES ACCRUED				1	240	12						
INTEREST ACCRUED					400	20						
RESERVES				1	240	14						
TOTAL				93	344	77						
NET WORTH												
CAPITAL STOCK												
COMMON				375	000	00						
PREFERRED				100	000	00						
SURPLUS AT FIRST OF YEAR				21	245	16						
NET PROFIT TO DATE				19	183	06						
TOTAL				515	428	22						
GRAND TOTAL	623	772	99	623	772	99						

FIGURE 3

in the stockroom. Obviously the general accountant has no place in his books for the myriad accounts of details occasioned by the constant flow of material thru the shop. Yet it is important that this information be at hand periodically, and it must be correct if it is to be of any use. Formerly it was considered sufficient if the balance sheet were drawn off yearly, the value of all material, raw, worked and in process being commonly obtained by actual, visual appraisal. While such an appraisal is still a very valuable procedure as a check, every modern accounting system requires a monthly statement like Figure 3, and some of the distinctions indicated can be reported accurately only thru a cost-finding system that keeps constant and accurate account of all movements of material and expenditures for labor. The cost keeper carries a separate account with each factory order, recording its increasing value as it progresses. When the accounting period ends he adds up his accounts, checks the balances against the total value of material, labor and expenses incurred and reports the value to be transferred from "raw material" to "work in process" and from "work in process" to "finished product."

The monthly statement illustrated in Figure 3 shows in a concise manner the status of all of the important activities of the business. Clearly, good cost finding should not stop at recording the values of the items just discussed. Just as Figure 3 is of great value in judging the general tendencies of the business, so more detailed reports of the several activities

of the enterprise show the reasons for these tendencies, and the furnishing of these detailed reports is a most important function of a good cost-finding system.

3. *Functions of cost finding summarized.*—It appears, therefore, that the requirements of a good cost-finding system extend far beyond the ability to find the cost of the product to be marketed. Its function as a means of predicting future performance has already been noted, and to these may now be added the third function, namely, that of supplying a basis for managerial reports. Summarized, then, these requirements are:

(a) To record the results of operations.

(b) To furnish a basis for the prediction of future operations.

(c) To supply a basis for managerial reports.

The last two items will be discussed in a later section, and the discussion for the present will be confined to the first item. The relation that should exist between the general books and the cost books will be clearer after a discussion of the problems of cost finding, so this topic will also be deferred.

4. *Complexity of costs.*—From what has been said it is clear that the cost of any manufactured article is a complex quantity. The manufacturer buys supplies which he classifies as raw or unworked material. On this material a certain amount of actual labor is performed by his men. Obviously it is not difficult to obtain a fairly accurate account both of the cost of the material used and of the actual labor bestowed upon

it, since these two elements of cost are paid for directly in money. But, in addition, it appears from Figure 2 (page 21) that many men must be employed who do not work directly upon the product, yet their wages are certainly a part of the cost of production. In addition also to the material that goes directly into the product there is much material that must be used to carry on the work, tho it does not enter into the product. Thus coal, oil, waste, etc., are chargeable against production, tho they do not enter directly into the product. And, finally, there are many other items of expense, such as depreciation, light, power, etc., that are neither labor nor material, but which must be included in the completed cost, tho they cannot be connected directly with any particular piece of product.

5. *Direct and indirect material.*—Material which enters directly into the product is known as direct material or more simply as material. All material which is chargeable against production, but which does not enter directly into the product is called indirect or expense material.

Occasionally material enters directly into production in such small quantities as to make accurate accounting impracticable. Thus glue, screws, nails, etc., may be used directly in production but not in quantities large enough to be worth noting, so far as any one piece of product is concerned. They are then treated as indirect material.

The iron, copper, insulation, etc., that enter di-

rectly into the construction of a machine would be classified therefore as direct material. The coal used in heating the factory and the oil used in lubricating the machinery of production, while not entering directly into the construction of the machine in question, are essential to its production, and portions of them are justly chargeable against it; however, they would be classified as indirect material.

6. *Direct and indirect labor.*—Labor which is expended directly upon the product is called direct labor, productive labor, or more simply, labor. Thus the work of a machine operator would be classified as direct labor, and his wages would be chargeable directly to the parts on which he works, in proportion to the time he spends.

All labor chargeable against production, but which is not directly connected with some particular piece of work, is called indirect or nonproductive labor. For example, the wages of firemen, crane tenders and clerical assistants cannot, in general, be connected with any particular piece of production. Yet they are just charges against production and must be included in the costs.

The terms "direct" and "indirect" are much preferable to "productive" and "nonproductive." All labor is productive, strictly speaking, tho it may not all be expended directly on the product.

7. *Burden or expense.*—It is not difficult to allocate the direct labor and the direct material which go into any piece of product, but it is exceedingly diffi-

cult, often to charge each piece of product with its correct share of indirect material, indirect labor and the other items of expense not directly connected with production, such as clerical salaries, insurance, etc. All these indirect charges are, therefore, usually gathered into lump sums, as will be described hereafter, under the name of burden, overhead expense or, more simply, expense. The great problem of cost finding is to distribute this burden or expense properly and justly over the product so that each article shall bear its own share, and only its own share, of expense. In general, this cannot be accomplished with great accuracy, but, as will be seen, approximations can be made that are sufficiently accurate for most cases.

8. *General classification of expense.*—The cost of the selling department and the accounting department is of the indirect kind, and hence is included in the expense. But, as has been noted, these functions are independent of production, are under their own officers, and the latter should be held strictly accountable for their own expenditures. The manufacturing superintendent should be held accountable only for the costs of actual production, and the cost books should show the relative proportions of expense chargeable to each department. Expense, therefore, is divided into manufacturing or factory expense, administrative or office expense, and selling expense. In many instances the administrative expense is small compared with the selling expense, and the two are grouped together under the name of general or com-

mercial expense. It will be assumed for the present that this grouping is sufficiently accurate for the discussion that follows, but the general principle should be borne in mind. It is often highly important that the cost of the sales should be carefully separated from the administrative or office expenses, in order to locate expenditures accurately and to fix responsibility beyond question; and where the selling expense is large compared with other expenses this separation should always be made.

9. *Elements of total cost.*—It appears, therefore, that the most natural primary divisions of manufacturing cost are direct material, direct labor, and manufacturing or factory expense. It is often customary to omit the qualifying word and speak of direct material and direct labor simply as material and labor. The sum of the direct material and the direct labor is known as the flat or prime cost. The sum of the prime cost and the factory expense is the shop cost, known also as the factory cost or manufacturing cost. The factory cost includes all expenditures for which the manufacturing superintendent is held responsible. The factory cost includes, therefore, all items properly chargeable against the product up to the time of its delivery upon the shipping floor or to the stockroom, according to its destination. The sum of the factory cost and the general expense is the total cost, and the total cost plus the profit is the selling price.

Naturally the relative proportions of these several

items will vary with the enterprise. In Figure 4, below, the relation of these items is shown graphically, and while the figures are taken arbitrarily, they are suggestive of the relative proportions found in general machine production.

The items which should be included in the total cost

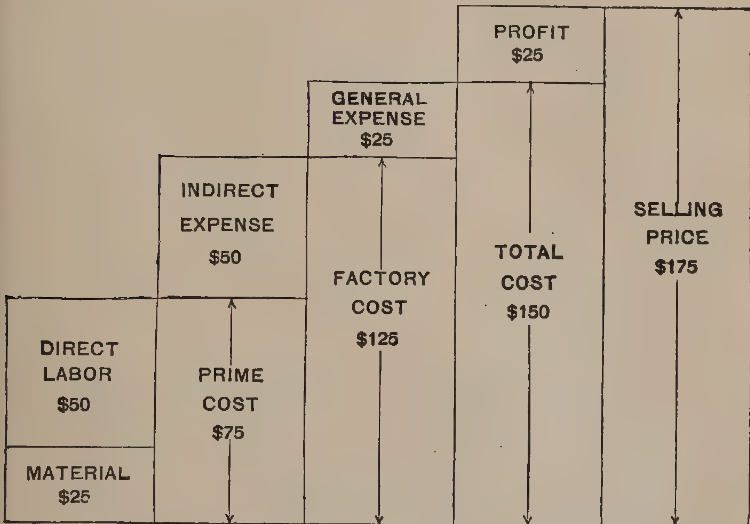


FIGURE 4. ELEMENTS OF MANUFACTURING COST

are necessarily fixed by the nature of the product, the processes of production, the efficiency with which the works are operated, and the cost of marketing the product. Profit, on the other hand, is somewhat arbitrarily fixed, but is closely connected with the volume of business transacted, a feature that is often lost sight of. Suppose, for instance, that the total cost of the

product for one year is just equal to the amount for which the business is capitalized, and on which it is desired to pay, say, six per cent profit. Obviously, if the total cost of the product is increased by six per cent in order to fix the selling price, this object will be accomplished. On the other hand, if the total cost for the year is small compared with the capitalization, the percentage to be added must be increased proportionately; while if this total is great compared with the capitalization it can be reduced in like ratio. The value of the annual output per dollar of investment is, therefore, a very important matter. It is not sufficient that the material and labor value of a product be low. The volume of the output must be sufficiently great so that the profit which must be added will not bring the selling price above what the market will stand.

10. *Methods of adding profit.*—The method of adding profit to the total cost as a percentage on that amount should be carefully noted where it is desired to use the selling price, instead of the total cost, as a measure of the profit. Suppose, for instance, that the total cost is \$100 and it is desired to make 20 per cent on the sales price in order to realize the proper returns on the capital invested. If 20 per cent of the total cost is added to the total cost the selling price will be \$120 and the profit will be \$20, which is not 20 per cent of the selling price. If, however, 25 per cent be added to the total cost, the selling cost will be $100 + (.25 \times 100) =$ \$125. The profit

will be \$25, which is 20 per cent of the sales price, and the profit will be correct in its relation to the desired returns on the investment. Operations of this kind, involving percentage, should be carefully considered, for they are a fruitful source of error and loss. Obviously, these calculations are simpler and safer when the total cost is used as a basis of computation.

In general, if s be the sales price, c the total cost, and x the percentage on the sales price that it is desired to obtain,

$$\begin{aligned} \text{then } s - c &= x\,s \\ \text{whence } s - x\,s &= c \\ \text{and } s(1 - x) &= c \\ \text{and } s &= \frac{c}{1 - x} \end{aligned}$$

which may be used for computing the sales price when the total cost and the percentage are known.

11. *Applicability of cost-finding principles.*—The preceding chapters have discussed the general problems of cost-finding, and it has been noted that these problems are common to practically all industries. They appear in farming, in commercial undertakings and in manufacturing industries. The most difficult cost-finding problems are to be found in machine-building establishments because of the variety of products and also of operations that are inherent in such work. For this reason a large part of the development of cost-finding methods has been in connection with machine shop operations, and the discussion which

follows is illustrated by many examples taken from this field. It should be remembered, however, that the principles that will be established are applicable, with proper modifications, to practically all industry, and a later chapter is devoted to a brief discussion of the application of these principles to typical enterprises.

REVIEW

What are the elements of prime cost; of factory cost; of total cost; of selling price? Prepare a diagram expressing the relation between the factors of selling price, and compare your result with the diagram in the text.

How would you allocate the following items of expense in a silk mill: raw silk purchases; dyeing; coal; commissions to salesmen; heat and light; weavers' wages; purchases of lubricating oil; superintendent's salary; general office salaries?

How would you work out a practical illustration of profits figured on both cost and selling price? Which, in your judgment, is the more accurate method?

Why are the terms "direct" and "indirect" preferable to "productive" and "nonproductive"?

CHAPTER IV

IDENTIFICATION OF COSTS

1. *Classification of accounts.*—From the foregoing it is obvious that cost finding is concerned with two kinds of accounts. Those that have to do with the actual production are constantly changing, a new account being opened with every new undertaking and closed with its completion. On the other hand, the accounts that have to do with repairs on buildings, maintenance and repairs of equipment and similar matters are permanent in their character, continuing without change so long as the enterprise lasts. The same is true of labor expense and material expense which cannot be allocated to any particular piece of work. They are expenses which flow constantly, tho varying in volume.

The first step, therefore, in establishing a cost system is to make a careful classification of these accounts. This classification will, necessarily, conform in its general outlines to the manner in which it is desired to have all transactions appear in summarized form in the general accounts, and also to the character of the statistical information which it is desired to col-

lect. The classification[1] will also necessarily vary in character and detail, according to the size of the enterprise and the character and variety of its product. The classification for a mercantile establishment will not be quite the same as that for a factory manufacturing machinery. The following is a typical classification of the general ledger accounts as found in enterprises of the latter class, with a few of the characteristic subheadings to show the kinds of charges belonging under each heading. A more comprehensive list is used by large manufacturing enterprises; one large electrical manufacturing establishment has over two hundred and fifty of these accounts. The justification of this large number lies in the fact that what may be a small item in a small plant may amount to many thousands of dollars in a large one, and the possibilities of saving more than offset the cost of segregating the accounts. This is especially true of the expense accounts. The monthly statement, Figure 3 (page 26), is, of course, a summarized statement of these accounts, arranged so as to show the totals of the several classes with only such detail as appears to be indispensable.

[1] For examples of such classification see "Factory Organization and Costs," by J. Lee Nicholson, p. 203, and also "The Science of Accounting," by H. C. Bentley, p. 85.

LEDGER ACCOUNTS OF A MANUFACTURING ESTABLISHMENT

ASSETS

Fixed	Current
Land	Cash
Buildings	Notes receivable
Machinery and equipment	Accounts receivable
Office equipment	Treasury stock
Patent rights	Consignments (outward)
Development expenses	Finished product
Organization expenses	Goods in process
	Unworked material
	Factory supplies

Miscellaneous

Deferred charges	Advertising prepaid
Interest prepaid	Securities owned

LIABILITIES

Fixed	Reserves
Mortgages payable	Doubtful accounts
Bonds	Depreciation

Current	Net Worth
Notes payable	Capital stock, common
Accounts payable	Capital stock, preferred
Accrued interest	Surplus
Accrued taxes	Profit and loss

REVENUE ACCOUNTS

Sales of product

Miscellaneous income

Sales of by-product

EXPENSE ACCOUNTS

Manufacturing Expenses

Direct material	Depreciation
Direct labor	Repairs
Indirect labor	Insurance
Factory clerical wages	Taxes on plant
Factory supplies	Etc.

Selling Expenses	Administrative Expenses
Salesmen's salaries	Officers' salaries
Traveling expenses	Officers' expenses
Agents' commissions	Directors' fees
Advertising	Clerical wages
Postage (used in selling)	Office supplies
Freight	Office rent
Cartage	Postage
Incidentals	Legal expenses

2. *Formation of subsidiary ledgers.*—It is obvious that the ledger accounts or controlling accounts, listed above, are necessarily fed from many sources. Thus if a piece of land or a new machine is purchased the transaction does not pass thru the manufacturing organization but is conducted thru the manager or superintendent directly with the real estate agent or the machine builder. The purchase price is added to the proper account under fixed assets, and the cash account, if it be a cash transaction, is lessened by the corresponding amount. If, however, the machine is built in the shop, as is frequently the case, a quite different procedure is adopted, and care must be exercised that the correct cost of manufacture is obtained by taking account of all direct and indirect ma-

terial and labor expended in its construction. If proper sales prices are to be fixed for goods manufactured for the market, the cost of every article manufactured must be ascertained, and if the general accounts are to be balanced frequently the value of all material—finished, in process and in the raw state—must also be evaluated frequently.

If the enterprise is small all of these requirements can be met by accounts in a single general ledger, the detail items under each account being consolidated to permit such treatment. But as any establishment grows it becomes increasingly necessary to go into greater and greater detail, and subsidiary ledgers are opened to handle this detail, the summarized statements of which may be carried to the general ledger. Thus it is often desirable, as explained in the Modern Business Text on "Accounting Principles," to open one ledger for accounts receivable and another for accounts payable. The cash transactions are often kept in a separate cash book, and a separate ledger may be necessary to keep proper account of the machinery and equipment. The number and character of these auxiliary ledgers will depend entirely on the size of the business and the character of the output.

3. *Separate cost records.*—When, therefore, the details of the cost of the product become too voluminous for the general books some form of independent account must be opened for each individual job or order. This series of accounts may be kept by means of a

card-index system or they may be kept in a bound volume, but in either case such a set of accounts is usually called a cost ledger. Just when it becomes necessary to open such a ledger cannot be definitely fixed, but depends again on the circumstances of the business. There is a general tendency, however, to separate the cost-finding system from the general books, even in certain kinds of small plants, for reasons that will presently appear. The extent to which this is necessary is also much affected by the character of the manufacturing processes and the consequent organization of the enterprise. Manufacturing plants may be divided, broadly speaking, into two kinds, namely:

(a) Continuous-process industries.

(b) Intermittent, or interrupted, process industries.

4. *Continuous-process industries.*—In a continuous-process industry of the extreme type the materials are passed in a steady stream thru a process or sequence of processes. The raw material goes in at the receiving end of the plant, is worked continuously, and appears as finished product at the shipping end of the plant. Thus a cement plant is supplied with a constant stream of the necessary ingredients, passes them all thru the same processes and produces a uniform product, so far as appearances, at least, are concerned. Ore-reducing plants, oil refineries, salt works and sawmills are other examples of this kind of industry.

Such an industry may be either analytical or synthetical. That is, it may take some natural product and separate it into component parts, as in the case of ore reducing or of industries turning out products made from salt; or it may take raw materials and build them up synthetically into other products, as in the case of a paint works. Usually such factories handle only a few materials and these in very large quantities.

In the extreme case where the processes involved are not numerous, and the quantities handled are vast and of few kinds, the cost finding is very simple. All that is needed is the cost per unit (yard, pound, or ton, as the case may be) and this involves only a record of the output for the period considered and a record of the labor, material and expenses incurred for the same period. If the value of the material in process is not great the unit cost can be ascertained accurately enough by dividing the summarized labor, material and expense by the output for the period selected. If, however, the value of the material in process is great, allowance must often be made for this value, especially if the rate of production varies. Clearly the cost finding, even in such cases, need not extend beyond the general books, and in simple cases it is not necessary to keep the expenses of production in any great detail, since these expenses are necessarily distributed uniformly over the product.

There are often administrative reasons, however, for keeping detailed costs even in these simple cases.

Thus, in some continuous industries it is desirable to know the cost of production by departments or processes; or the plant may be producing several articles continuously, each article passing thru the same departments. In such cases simple division of the summarized cost, as already indicated, may not suffice, and cost-finding methods apart from the general books must be resorted to.

5. *Intermittent-process industries.*—At the other extreme are industries that manufacture a variety of products and a comparatively small number of each variety. A plant for the building and repairing of ships is a good example of this extreme type. Here duplication of an order is not frequent, and the greatest diversity of product is met with, as regards both character and size. Obviously, only cost-finding methods that take account of the labor, material and expense that justly belongs to each job are adequate in such cases. The degree of detail into which it is necessary to carry the cost-finding methods will, of course, vary greatly with the character of the work, but, evidently, no simple averaging methods, such as have been discussed, will give even approximate costs in cases like this. The various items of shop expense are chargeable in varying degree to the many articles made, and, while it is not difficult to allocate the material and labor actually used on any contract, the distribution of the indirect expense presents a difficult problem.

6. *Combined intermittent and continuous factories.*—

Between these two extremes are found many enterprises that employ both intermittent and continuous processes to a greater or less degree. Thus a large electrical-machinery factory may build large-sized generators, motors or transformers, to order only, and seldom in lots of more than three or four. On the other hand, it may also build a large number of small motors or transformers, these articles not being in continuous production, but passing thru in large lots as needed. Large numbers of finished parts may be made at any one time and placed in the storeroom to be assembled whenever desired. Again, certain processes such as annealing and dipping in insulation may be in constant operation, like a continuous process, tho all the sheet steel passing thru may be handled and identified as belonging to certain specified lots and intended for specific jobs. The porcelain works of such a factory, if it were making porcelain parts of approximately the same size, might very well be treated as a continuous industry and the cost of its output might be computed by the unit plan, as in the extreme continuous industries discussed above. The same procedure might be followed in the foundry, if the manufacturing conditions were analogous and no great variation in the size and character of the product existed.

Obviously the conditions in such a factory are complex, and the cost system that will be adequate for such a place needs careful consideration and may include characteristics of more than one method of cost

finding. Clearly, also, no single method of cost finding is applicable to all kinds of industry, and many practical modifications must often be made in cost-keeping theory in order to obtain a workable system. In most cases exact results are not obtainable, because of such complexities. There are, however, certain fundamental conceptions that are helpful in all cases.

7. *Blanks and forms for cost finding.*—It is obvious also that, where a factory is highly departmentized, as in Figure 2 (page 21), special means must be employed to coordinate the work of the several departments and to insure that correct information shall go to the right persons and to those persons only. Such information cannot be carried orally, but must be transmitted by means of systematized blanks or printed forms. Furthermore, the amount and character of the "system" used will vary widely with the character of the industry, the size of the plant and its particular form of organization. The card or form that will be excellent for a particular purpose in one factory will be useless for the same purpose elsewhere. No effort is made here, therefore, to illustrate such forms or blanks except as it is necessary to illustrate general principles. If the purpose of the blank can be clearly determined the exact form of the ruling and of the printed content is a matter of clerical work only; tho, of course, much valuable information and assistance can be obtained from the

collections of such documents that are found in specialized books on cost finding and on accounting.

Even where the cost-finding system is elementary, and does not extend beyond the general books, it is important that the blanks and forms used in administration be made with the cost system in mind. Much valuable time is often wasted in copying and recopying instructions or records that should appear in the required form as a natural result of the system. When, however, the detail costs required are such as to warrant the employment of a cost keeper, and the opening of special ledgers, such as the stores ledger and the cost ledger, the forms and blanks used must cover thoroly the system introduced. The manufacturing superintendent is concerned with placing proper orders for producing machines. The cost keeper is concerned with the detail in which these orders are given, since on the detail in which the order is given must rest the detail in which his cost will be recorded. The set of forms, therefore, should serve both purposes, namely, that of carrying the correct information as to the method of doing the work, and at the same time that of segregating operations in such a manner as to allow the intelligent recording of costs. No one thing is so fatal to system of any kind as complexity. Every effort should be made, therefore, to keep the number of the blanks down to a minimum consistent with the absolute requirements of the situation.

8. *Two classes of blank forms.*—A large manufacturing enterprise may employ a great number of these blanks and forms, and to the uninitiated this vast array is often very confusing. There are, however, only two general types of such documents, and it will assist materially in an understanding of complex systems if these blanks are classified into:

(a) Orders, or instructions as to how work is to be done.

(b) Returns, or records of how work has been performed.

Orders include all instructions or advice emanating from all departments and officials that are charged with directing the work. Thus, the drawings and specifications issuing from the drafting room, and the information regarding shipping dates and destination of product, may be regarded as orders, just as much as the specific orders that must be given to a mechanic regarding a particular piece of work. It may be further helpful if these orders are considered as moving downward in Figure 2 (page 21) over predetermined paths, each one carrying its information accurately to the right parties and to them only. In large organizations it is now common to make such a chart as Figure 2 and lay out such paths; also to specify the character of the orders that are to move along each one. Figure 6 (page 64) illustrates a production order issued by the order clerk (Figure 2); instructing the foreman of some department, perhaps, to proceed with some operation. The produc-

tion order carries the number, letter or other characteristic which indentifies the work, whether it be a lot of machines, a single machine or a part of a machine, and, obviously, the detail in which it is made out will govern the detail in which the returns can be made.

Returns include all statements that give the results of operations or the records of material used, whether for direct product or for supplies; also records of time expended and wages paid. Returns may also include all summarized reports and similar documents. These returns have their origin where the work is being done and where material is being drawn from stores and worked into finished product. It may assist in the visualizing of these matters if returns are considered as moving upward from the points where the actual operations are performed, being constantly consolidated into briefer statements till they are merged into the general books and general consolidated reports. Figure 8 (page 83) shows a typical work card on which may be recorded the amount of time expended on any given operation and the rate of pay which the operator is to receive. This card bears the order number or letter which has been assigned to this particular operation and piece of work and is, therefore, a basic factor in cost finding, whether it refers to a lot of machines or a minute detail of any one of them.

9. *Necessity of identifying work.*—If costs are to be obtained, whether of large lots of machines, a

single machine, or of each part of a machine, some means must be provided for identifying the lot or machine or part. No two machines or parts may bear the same distinguishing mark, and if many thousands of pieces are passing thru the works at any one time it is obvious that some system must be adopted that will be capable of great expansion without danger of repetition. Furthermore, constant reference must be made to the several departments of the factory. To write the names of these departments out in full would take too long and would be a waste of labor. It is customary, therefore, to refer to departments by number or symbol. Again, in making up shop orders it is necessary to specify the operations, or sequence of operations, on each piece. This also may involve reference to tools and equipment. In a large works the tools and equipment may be many and diverse, including many special jigs, fixtures and similar apparatus; the number and character of the operations performed may also be many and varied. Furthermore, the materials used may be of many kinds and, since constant reference must be made to them, they also should be the subject of abbreviated momenclature. With the constant and rapid growth of the methods of planning all operations in advance, as advocated by modern production engineers, these last items assume great importance in factory administration. The more accurately all machines, operations and materials are identified, the more accurately and easily can production costs be allocated. The

laying out of a good system of identification is, therefore, a necessity, whether viewed from the standpoint of operating administration or of cost finding.

10. *Mnemonic symbols.*—There are several identification methods now in use. In many places the departments are known and referred to by simple letters, such as A, B, C, D. Where only a few departments are to be handled this method is adequate. If the departments are numerous, and it is desired to apply numerical identification to other lines, a system of mnemonic symbols is often employed. Thus the letters T A might be used to indicate the transformer-assembly department, the letters S M might indicate the screw machine department, and so on. Similar abbreviations are commonly employed to indicate the materials used. Thus C I indicates that the part is cast iron; M S, that it is of machine steel.

The problem of identifying operations is a little more complex. If only a few operations are in use, mnemonic symbols are adequate and are often used. Thus TN may signify turn, BO may mean bore, GR may signify grind, and so on, each enterprise compiling symbols suited to its own operations. Sometimes the use of symbols is obviated by printing all the operations on the side of the cards which give instructions or record returns, as illustrated on the work card, Figure 9 (page 85), in such a manner that the facts may be indicated by a check mark. This method also saves writing, but its use is limited to industries involving standard operations.

The problem of identifying departments or operations is, in general, an easy one compared to that of identifying the products and parts of products, particularly in large plants doing a wide range of work. In factories which make large products, such as steam engines, and where a comparatively small number of machines are being produced at any one time, mnemonic methods are sometimes used. Thus, in some shops of this character the term "Osp" might be used to designate all drawings for an engine built for a certain hospital, and each drawing might bear this symbol followed by a serial number which would locate the drawing in the series belonging to that engine, the drawing serving as a basis for production orders and cost charges.

11. *Drawing numbers.*—In large factories with a variety of products, however, these simple methods of identifying machines and machine parts fail completely, and identification must usually rest upon a carefully arranged system of drawing numbers, so called. In a very large works where many thousands of drawings are made yearly, this necessitates a careful consideration of the entire manufacturing problem, and perhaps the separation of the product into distinct classes. Here mnemonic or in fact any system of symbols based entirely on letters is usually inadequate or too cumbersome, and numbers, or combinations of numbers and letters, are used. Thus the symbol K 24,689 might, in such a system, identify the drawing of a steam-engine cylinder, the letter indi-

cating the class of product, and the numerical part indicating its place in the series. Sometimes, again, all drawings are numbered serially, and an index is kept which shows the serial numbers of the drawings used for each machine. The drawing of any part may be found by looking at the index of the drawings that were used in making the machine and finding the serial number of the particular drawing on which the part would be found. Sometimes, too, a numbering system based on the Dewey decimal system of classification is used, certain classes of numbers being set aside for certain blocks of machines or product. Thus, all numbers beginning with .012 might indicate transformers and all numbers beginning with .013 might indicate oil switches. In practice the decimal point is omitted for convenience, and the integers in the number are always preceded by a cipher. The Dewey system has the advantage of unlimited expansibility without repetition; it can be made as comprehensive as may be desired, and hence is well suited for large works. The system that is best for one shop may not apply to others, however, and each case requires special study in order that the system may be made comprehensive without being cumbersome.

Whatever the general method of classifying the drawings, each drawing may carry more than one part, tho in some systems only one part is put upon each drawing. Where more than one part appears on a sheet each may be identified by a part letter.

Thus, in such a system, K 24,689-A might signify part A on drawing 24,689 of the class of product indicated by K. This identifies the part beyond question, making it possible to charge with accuracy all labor and material that enters into its production.

12. *Drawing lists.*—In most well-organized shops using methods of this kind, the engineering department originates the directions governing the constructive features of the work, and turns over to the construction department full drawings and specifications in such detail that every part may be identified, not only during actual construction, but for all time, so long as the drawings are existent. In highly developed systems a drawing list, Figure 5, opposite, accompanies the drawings and specifications. Such a list constitutes a complete inventory of the parts that are to be made, and is an index to the drawings and lists, where the parts may be found in detail. Thus in Figure 5 the number of the drawing and that of the part or piece, are listed, the material of which the part is to be made is noted, and the number of the parts required is given. Reference is also made to the engineering and other specifications that accompany the drawing. Figure 5 illustrates a system which uses the Dewey decimal method for numbering drawings, but which uses a combination of letters and integers for other documents, such as tabulated data and engineering specifications.

It will be noted that such a method allows the free and convenient use of any one part in the construc-

DRAWING LIST NO. 4

MACHINE	TYPE	CLASS	VOLTS	DATE
Generator	M.R.P.	10-400-650	2200	4-11-192–

NAME OF PART	DRAWING NO.	PATTERN NO.	PART NO.	NO. OF PARTS	MATERIAL	DATE ADDED	DATE CHANGED
MACHINE COMPLETE	012						
" OUTLINE	0121						
ARMATURE COMPLETE	0122						
" DIAGRAM	0123						
" FRAME	0124		a	1	CI	8-29-14	
" PUNCHING	0125		B		m.2.S		
BASE	0034		a	1	CI		
BEARING	0035		B	2	CI		
BRUSH							
BRUSH HOLDER							
" STAND							
" STAND SUPPORT							
" STAND BRACKET							
" STUDS							
" YOKE							
CABLE							
" FOR FIELD							
" COUPLING							
COLLECTOR	Table	P468	m	2			
CONNECTION BOARD	Table	R246	n	1			
COUPLING	Table	n428	R	1			
FIELD SPIDER	0126		a	1	SC	8-24-15	
" RING	0127		B	1			
JACK SCREWS	Table	S26	a	2			
LAMINATED POLES	0128						
PULLEY	Table	[illegible]	R	1			
RAILS							
SHAFTS & KEYS	0346		a	1	mS		8-16-15
SPOOL COIL	0267		B	1			
STANDARDS & CAPS	0436		C	2			
WRENCHES							
Armature Shields	0074		B				9-12-14
Sub-base	0346		a				
Wooden base-frame	0014		C				
LIST OF CASTINGS			00				
ARMAT. WIND. SPEC.	a 4684						
FIELD WIND. SPEC.	B2678						
ENGINEERING NOTICE	m 46						

FIGURE 5

tion of any machine, whether designed originally for it or not, since identification is complete. Thus, in Figure 5 the armature and field are taken from one series, the shaft and bearings are taken from other series, and still other parts were made originally for other classes or sizes of the same type of machine.

The nomenclature given in Figure 5 has been taken at random, but it is a probable combination. In well standardized production such lists may be printed in outline and the data filled in by hand. Thus in Figure 5 the data that would be so filled in are indicated by script. It will be evident that the shop orders governing the production of the machines, as a whole or in part, as the case may be, and the shop returns recording the details of such production, can be made out with the assurance that, so far as identification is concerned, the correct labor and material charges will be recorded against the cost of the part concerned.

13. *Mnemonic and number systems compared.*—The relative merits of mnemonic symbols and numerical identification should be noted. No doubt, in the cases where the number of items is small and where it is desirable to remember departments or operations, the mnemonic system is useful. For this reason it is often used to identify departments and operations. It is also used to identify expense orders. Thus all charges against buildings can be carried in account B, and all charges against power, heat and light, against account P. H. L. In large factories, however, where it is necessary to separate the expense into

many items, it becomes necessary to use numbers. Thus in making a labor report the expense may be charged against numbers, while the direct labor is charged against the letters which identify the several classes of product.

Obviously, the degree of detail needed in the nomenclature of a factory depends entirely upon the character of the enterprise. In simple, continuous industries few details are required in the nomenclature, while in large, intermittent industries it may be necessary to go to all the detail which has been described. Whatever system is adopted it should identify each part beyond a doubt, and it should be capable of extension as the industry expands. To change the system of nomenclature and identification is always a troublesome problem and one that can often be avoided by a little foresight.

It is important to have clearly in mind the principles that have been discussed in this chapter, since upon them depend the methods used in collecting the material and labor charges, whether against the job as a whole or against any detail. The need of such detailed methods of identification will be clearer after a discussion of the principal items with which cost keeping is concerned, namely, materials, labor, and expense.

REVIEW

Under what headings would the following accounts be placed, advertising; office expenses; land; indirect labor; taxes; accrued taxes; factory supplies; salesmen's traveling expenses; sales of product?

What are the characteristics of a continuous-process industry; of an intermittent-process industry; of a combined continuous- and intermittent-process industry?

For your own information, classify the following industries as continuous-process industries or intermittent-process industries: a shoe factory making one grade of men's shoes; a shingle mill; a chemical factory; a tannery.

How would you designate the following expense accounts of both a wholesale and a retail sales department by mnemonic symbols: salary of manager; clerk's wages; traveling expenses; advertising; rent; light; telephone; miscellaneous?

CHAPTER V

ISSUING AND EVALUATING MATERIAL

1. *Issuing materials in general.*—It is a cardinal principle in good cost-finding systems that no material of any kind should be issued from the stores without a requisition which indicates the authority for the transaction and the account to which the material is to be charged. It is true, of course, that in small shops, particularly where the material handled is of no value for personal use, it will not pay to employ a storekeeper; workmen may be allowed to help themselves from open bins or racks. As previously noted, these cases are rare. Generally it pays to have a storekeeper, whether detail costs are kept or not. He will, as a rule, save the company more than enough to pay his wages. It is universal experience that workmen when allowed to draw either direct or indirect material from the stores without check, become careless and wasteful, not only as to the quantity drawn out, but also as to its economical use. Loose storeroom methods are also likely to lead to dishonesty, pilfering and bad habits generally, on the part of employes. Aside from the actual saving made by properly regulating the withdrawal of material from stores, such

regulations serve to accentuate constantly the value of material, whether direct or indirect in character.

2. *Requisitions by foremen.*—The simplest way to arrange for the drawing of material on requisition is to empower the foreman to issue the required requisition. The foreman is provided with an order book, and no material is issued except on an order describing the material, its amount, and the purpose for which it is intended. This system is simple and flexible. It responds quickly to any emergency, and for this reason it is particularly applicable in the case of small shops. There is no delay in getting material from the stores to the production floor, and in a shop doing repair work this is a valuable feature. In many small shops, where the work is more or less uncertain in character, the number of men employed is small, and refined cost-finding methods are not necessary, this simple system will answer all requirements. It certainly is a vast improvement over the loose methods so often employed in small shops, where every man helps himself and where no check whatever is put upon wastefulness.

If, however, the enterprise is large and each foreman has many men under him, it is not good policy to fill up his valuable time with clerical duties. He has usually too many other important functions to perform,[1] and if pressed for time, as he usually is, he

[1] Mr. F. W. Taylor's paper on "Shop Management," particularly that part dealing with the many duties of the average foreman, in the "Transactions of the American Society of Mechanical Engineers," Vol. 24. deals with this subject in greater detail.

will not do this requisitioning well. A busy foreman who is expected to maintain a large output from his department will not be particular or accurate in making out bills of material for marketable product; and if he is also obliged to write orders for supplies and indirect material, he will naturally be very inaccurate in regard to the distribution of the cost of these items. He can, of course, be given a clerk to help him in this work, and this assistance may answer in certain kinds of moderate-sized plants. From the standpoint of intelligent cost finding, however, even this method is unsatisfactory, and it fails for reasons that will follow. In fact, when the situation warrants the employment of clerical help of this character, it is time to discard a simple system for something more advanced and more accurate.

3. *Planning production in advance.*—Brief mention was made in Section 5, Chapter II, of the growing tendency to separate all planning functions from those that have to do with production. This is well illustrated in the engineering department, where all structural plans are made entirely aside from, and in advance of, actual production. A similar movement is making rapid progress in the production department proper, looking to the planning of all productive processes in advance of the actual productive operations. The writer uses the term production department to designate the entire productive organization under the superintendent of production, and not in the narrow sense in which it is often employed to

designate what is really nothing more than a planning department. Planning departments are being introduced quite rapidly, and the growth of this idea should be studied by those interested in cost finding.

A planning department aims to do for the productive branch of the factory exactly what the engineering department has accomplished for the scientific branch. The engineering department predicts what is to be done; the planning department aims to predict how and where the work is to be done. The planning department is, of course, an integral part of the production department.

Obviously, the degree to which it is possible to predict methods of production will depend on the character of the industry and the amount of study that has been put upon this phase of the particular industry under consideration. In general, the possibilities of predicting the results of production are as yet only partially developed, but progress is being made in this direction, and it should be carefully studied in connection with cost-finding systems; for the general philosophy that underlies these movements holds true also for cost finding and is closely connected with its growth. The discussion, for the present, will be confined to the problem of finding costs as they accrue, but a later section will discuss the more advanced idea of predicting costs in advance of construction.

4. *Specifying the material.*—It should be noted in this connection, however, that if costs are to be determined intelligently, the methods of securing them

must be planned in advance. Just as the designing engineer should plan in advance all the constructive features of the product, and just as the superintendent of production should foresee all his productive processes, so the cost keeper should know in advance what costs he needs to collect and should lay his plans to collect them without, at the same time, gathering a mass of information he does not want. One of the most common and most drastic criticisms that is applied to many cost-finding systems is that they waste money in finding detail costs that are not useful, while neglecting, perhaps, cost data that are extremely valuable. It is for this reason, as before noted, that a good cost system cannot be installed in the abstract. It must be prepared with special reference to the particular business in which it is to be used.

In a well-organized modern factory of the intermittent type, therefore, the engineering department will turn over to the production department drawings and specifications which show just what is to be done. Each piece called for will bear an identifying number or symbol, as explained in Chapter IV. In best practice the engineering department will also furnish complete bills of material showing in detail just what direct material is needed for each part. Detailed statements such as these enable the order clerk, or whoever is charged with the duties of that office, to authorize with accuracy the withdrawal of material from the storeroom, and also, as will be seen, to identify the material with the costs of fabrication that

belong to it. Where material lists are not made out by the engineering department, bills of material are made out by the order clerk (Figure 2, page 21). Obviously, the more accurately these material lists are compiled, the more accurately can the raw material be drawn from the storeroom.

TO DEPT.________________ **PRODUCTION ORDER** ORDER NO.__________
DATE OF ISSUE______________ DRAWING NO.__________
TO BE COMPLETED BY _______ PATTERN NO.__________
DELIVER TO DEPT. __________ SPECIFICATION NO.______
CLASS NO.__________

PLEASE EXECUTE THE FOLLOWING ORDER RETURNING THIS SLIP TO STOREKEEPER ON COMPLETION OF WORK
CHARGE ALL LABOR AND MATERIAL TO THE ABOVE PRODUCTION ORDER NO.

DESCRIPTION OF ORDER

QUANTITY AND DESCRIPTION OF MATERIAL TO BE USED		DATE NEEDED	DEPT.

DATE ORDER COMPLETED______________________ APPROVED______________________

FIGURE 6

5. *Production orders.*—The order clerk can now issue a production order, as illustrated in Figure 6, above, to the foreman under whom the work is to be done. If the amount of material to be drawn is comparatively small, this production order may also be, for convenience, the material list, as illustrated by Figure 6. This is not an essential point, however, since the material list may be on a separate sheet, or

may be a permanent record, made on the drawing itself. The production order will, in general, give all necessary information regarding time of completion and the disposition of the part when finished. This order will also bear the specification number or the drawing number of the part referred to, and the production-order number to which the cost of the production is to be charged. Thus the part is identified with the time cards recording the details of its production, which are to be returned from the factory.

Clearly, the issuing of production orders requires not only an intelligent understanding of the costs that are desired, but also a thoro comprehension of the manufacturing problems concerned. A single production order might be made to cover a battleship, or a separate order might be issued for every individual part going into this same ship. On the one hand it, may be of great importance to know with accuracy the cost of one line of goods in which competition is very keen, whereas, on the other hand, in some other line, where the margin of profit is very high, it may not pay to obtain very accurate costs.

The detail in which it is necessary to know the cost of the several parts of a machine will vary with the machine and with the conditions, and the grouping of the several parts under production-order numbers requires good judgment. Furthermore, if best results are to be obtained, the order clerk must keep in mind the uses that are to be made of the cost data

after they have served to determine the costs of production. If these data are to be used as a basis for managerial reports of a comparative nature, this fact may somewhat influence the issuance of the production orders. Obviously, also, if segregated expense accounts such as are listed in Section 1, Chapter IV, are to be maintained, all expense material must be drawn from stores in such a manner that it will be accurately accounted for. It requires a high-grade man to place production orders so as to get the results desired and yet not waste money on details that are not necessary.

6. *Instructions to storekeeper.*—The production-order and material lists are usually made in multiple, one copy going to the foreman concerned, with all drawings and specifications connected with the work, and constituting his permanent authority for doing the work. Another copy goes to the storekeeper, furnishing authority for issuing the material when it is demanded by the foreman. A copy is, of course, retained by the order clerk. The storekeeper or his assistant issues the material called for, cancels his copy and corrects his record of material on hand, either at the bin, or on the stores ledger, if one is kept. If a stores ledger is kept the record of the transaction may be recorded under "issues" on the proper stores ledger sheet. The production order can then be evaluated, the price per pound or piece being filled in, and it can be forwarded to the cost department to be incorporated into the cost of the part to which

the particular production number belongs. A similar procedure could be followed with the simpler form of requisition issued by the foreman, but, for reasons previously pointed out, requisitions thus originated are apt to be inaccurate.

Theoretically, this method is very accurate. In practice, however, it is difficult to specify with absolute exactness every item of direct material needed; but, except in the case of very complex work, the errors need not be serious. The chance of error is more than compensated for by the manner in which the method prevents unnecessary withdrawal of direct material, and fixcs the proper authority and responsibility for withdrawal in such a manner that errors and irregularities can be instantly traced to those responsible.

7. *Emergency requisitions.*—A great objection often made to such a system is that it is not flexible under emergencies, and that small jobs always cost more when passed thru such a system than they would if managed by a simpler one. For example, when a serious breakdown in the machinery of production occurs there is little time to make bills for material and to write requisitions for them; and when repairs are being made while the factory is temporarily idle, a rigid requisition system may be embarrassing and may greatly hamper the progress of the work. Again, in making commercial repairs it may not pay to make drawings, or even sketches, and write out bills of material based upon them; moreover, when

this procedure is carried out the cost of such repairs may be excessive.

These defects can be partly obviated, however, by empowering some official to issue emergency requisitions to take care of these special cases. In such instances the official possessing this emergency authority would issue the material requisitions that are needed, and have proper production orders assigned as soon as possible thereafter. Provision must always be made for caring for emergencies in any system, or its inflexibility may destroy its usefulness. Many good cost systems and other systems have failed on this account. Some, in fact, have been unable to obtain even a good foothold in shops where they were being introduced, largely because impatient foremen or superintendents, who are being hard pressed for production, fear that a new system will destroy flexibility, even tho, perhaps, it improves other manufacturing conditions.

The foregoing discussion has reference largely to manufacturing enterprises of the intermittent type, tho the principles are general and apply to many other forms of industry. As the enterprise approaches more closely the other extreme, or continuous operation, the necessity of detail becomes less and less, until finally no production order for direct material may be needed, since all material will be purchased in large quantities and its value will be carried directly to the general books.

8. *Requisitioning indirect material.*—Indirect ma-

terial, such as coal, waste, oil, brooms, and the like, is not handled by production order. Usually this class of material is drawn on the foreman's requisition. It is still customary in some factories to have the foreman assign the order number to which the supplies drawn are to be charged, this number being, in general, the production-order number on which the workman is at the time employed. It is indispensable if we are to obtain an intelligent and thoroly accurate view of costs, that such supplies should be charged to standing-order numbers and distributed by one of the methods to be discussed. The storekeeper evaluates the foreman's requisition for indirect material and sends it to the cost department. It should be noted in passing that where supplies are drawn in very small quantities it is difficult in some cases to keep an exact record. Thus it would be difficult to keep an accurate record of lubricating oil; supplies of this kind are often charged in a lump to the proper expense order. But even in such cases it is a useful check on waste to issue the supplies only on a requisition.

9. *Valuation of issued material.*—The value of material stored in the bins of the storeroom is necessarily somewhat greater than the purchase value of similar material. Freight, cartage, the handling of the material in storing it, rent, or interest on the building investment, insurance, wages of storekeepers, waste, shrinkage in use, as by saw-cuts and remnants, defective pieces, repairs and other storeroom

expenses, are all necessary expenditures which are incurred in order to obtain the advantages of having material ready for immediate use. This expense should never be overlooked in evaluating the material issued from the stores, particularly if material should be shipped directly to a customer from the storeroom, as is done in mercantile establishments. Unless the billing price of such goods is an advance on the market price paid for them, it is evident that a loss will be incurred. In fact, it is sometimes more profitable for a factory to order standard material to be sent directly from dealer to customer than it would be to fill the order from the storeroom bins.

Furthermore, material is crystallized capital which is earning no interest. It is perfectly proper, therefore, to charge against it the interest that it should earn; and this, again, adds to its value. Materials also may depreciate in value while stored, and while this loss in value is a proper charge against production it is usually more convenient to handle it in a manner separate from those methods now to be discussed.

In the simpler and merely approximate methods of cost finding, all storeroom expenses are carried to the factory-expense account and charged off as part of this expense. While this insures that the total of such expense is cared for, it does not distribute it logically, and many of the modern methods of cost finding distribute storeroom expense as a percentage on the value of the material issued. This, as will be seen

later, is in accord with modern tendencies, which aim to allocate all expenses, as far as possible, to the particular activity to which they peculiarly belong. The value of issued material should, therefore, be determined by adding freight and cartage to the invoice price of the goods and then adding a percentage to cover storeroom expenses. See Section 2, Chapter XIII.

Now, the invoice price of the same goods changes constantly with the changing market price. The material in a given bin may have cost more, or less, than a new lot which has just been added. To equalize this difference in prices, the total value of the entire lot may be divided by the total combined number of pieces or pounds and a new average rate determined in which such price differences disappear.

10. *Value of material in process of fabrication.*—It will be noted that the foregoing storeroom methods do not take cognizance of materials that are in process of fabrication. Modern accounting methods, however, often require regular and frequent statements of the financial conditions of the enterprise. If the latter is of the continuous type, where the value of the material in process, at any time, is not great, the methods described above may be adequate for all purposes. In many cases, however, the value of the material in process is very great, and no correct statement of the business can be rendered without taking it into account.

It is obvious that it would be well-nigh impossible

to keep account of the cost of the material in process by simply adding to its value the value of the material drawn from stores, and subtracting the value of the material delivered to the stores or the shipping room. For this reason, even in factories where some lines of product are in continuous production, it is customary to pass the product thru the factory in lots, a production order being issued for each lot. If a cost ledger is kept, an account would be opened for each lot under its own production number, and all material which went into the lot would naturally find its way to this account and could be evaluated at any time. The total value of all material appearing in the cost ledger is the value of all material in process.

11. *Value of finished parts.*—So far as the production department is concerned, finished parts manufactured for stores do not differ from other products, and they should bear their full share of all indirect expense. This should be kept in mind in evaluating such parts, since factory expense is an integral part of shop cost. Thus, one manufacturer might buy from another manufacturer some finished parts, such as gears, for instance, storing them in his regular storeroom, and issuing them to the factory at the cost price plus the cost of handling them in the storeroom. Or he might make these gears himself, keeping account of all labor, material and indirect expense involved in their production, and then deposit them in his finished-parts storeroom, assigning to them the value thus determined.

In issuing such manufactured finished parts to customers for repairs, they would, of course, be charged with their proper share of general expense and with an allowance for profit, just as in the case of any other finished product. In issuing them to the production department to be used in assembling complete machines they would be treated like any other material or finished parts that have been bought elsewhere. Care must be exercised, however, to see that expense charges are not duplicated. Thus, if the material value is used as the basis in distributing the expense it would not be logical to charge the expense on this basis when putting the finished parts into the storeroom, and then to duplicate this procedure when the parts are assembled into finished machines. The best method of distributing the expense on finished parts will be clearer after a discussion of the methods by which such distribution is accomplished. This matter is treated fully in Chapter VIII.

12. *Value of finished product and stock.*—When a product is made to order it is usually shipped to the customer when completed, the factory cost is summarized from the cost ledger or corresponding record, the necessary additions for general expense, selling expense, and profit are added and the transaction is closed except for the collection of payment. Where the product is made in anticipation of the market, and especially where production necessarily is in large lots, the finished product must be held in storage till sold. A large factory may have not only

a large stock of finished goods in the central stockroom at the factory, but also branch offices which carry such finished product. The amount of money so tied up may be very great.

The general and selling expenses are usually distributed over the product as a percentage on the factory cost. It is no longer necessary to keep the labor and material components of cost separated. The cost-ledger account may therefore be closed, and the finished product may be listed on the stock records at factory cost. The methods of distributing general and selling expenses will be discussed in a later section.

It should be carefully noted that the factory cost placed upon the product when it is deposited in the storeroom is not necessarily the permanent value of the article in question. The factory cost represents the investment in labor and material up to this point and, like any other investment, it may change in value. Theoretically, if the article should lie in the storeroom for a year, its *actual cost* to the factory management would be increased by the interest on the investment and the cost of storage. Practically, however, most product begins to deteriorate from the moment of its production, either from the action of the elements or because of progress or change in the methods by which the product is manufactured. A full discussion of this phase of material values may be found in Chapter IX.

13. *Material wastes.*—A most important feature of the care and accounting of materials is the matter

of waste. Every factory has its own peculiar sources of waste. These should be carefully located and their effect minimized as far as possible. Wastes are of two general kinds; they may be classified as avoidable and unavoidable wastes. Those due to carelessness in handling or overissuing material are what may be called avoidable wastes, as are also losses by pilfering, or from the diverting of material from the factory in any way without compensation. A well-kept stores ledger and a careful periodical checking up of material on hand will minimize losses of this kind. If more material is issued than is actually needed for the work in hand serious loss is sure to occur. Material left over from productive work is not likely to be returned to stores unless a special effort is made to bring this about. Ordinarily it will lie around the shop in boxes and under benches, and much of it will find its way into irrecoverable scrap. Material requisitions should, therefore, be drawn with care to minimize this form of loss, and any material left over from a given job should be carefully returned to stores and credited to the work for which it was originally requisitioned.

Unavoidable wastes are such wastes as are incurred in cutting up material. Thus the waste due to cutting up copper bars, either by saw cuts or under presses, may be considerable. Even with cheaper material, as, for instance, sheet steel, where large quantities are used, the value of the scrap may be great. If the waste is in such form that it may be returned to

stores and used for other purposes, the job in question may be credited with the value of the scrap incident to its production. In fact, in some cases if this procedure is not followed the material cost will be prohibitive. But in any case all scrap and waste should be carefully noted and, if salable, it should be gathered up and stored, pending such sale. Not the least important feature in the handling of material is to impress on foremen and workmen the fact that material represents money and should be treated accordingly.

It will be clear that the value of the material purchased, as recorded in the general ledger account, may, and generally will, exceed the value of the material as charged to production, in the cost ledger, by the amount of the storeroom wastes and losses. Storeroom losses from pilfering or carelessness, or from overissuing or from issuing without a requisition, do not appear in the costs, and sometimes these losses are considerable. In some kinds of manufacturing such differences are difficult to check up; but wherever it is possible this should be done periodically. A similar discrepancy may exist between the time paid for on the pay-roll and the time charged by the cost system against the same piece of production. It is generally easier, however, to minimize this difference in the case of labor than it is in the case of materials.

REVIEW

Rule from memory a form of production order. How does your ruling compare with that of the text?

What are the movements of the production order, from its origin to its final destination?

What are the usual causes of discrepancy between the physical inventories and the book inventories? What steps would you take to reduce the discrepancies?

On what basis would you distribute storeroom expense?

How should valuation be made of issued material? Of finished parts?

CHAPTER VI

EVALUATION OF LABOR COSTS

1. *Recording time by checkboard.*—No matter what wage system is in use in the factory, it is usually desirable to record the time at which every employe enters and leaves the works. In very small plants the foreman is usually depended upon to enforce regularity, but the limitations to this method are obvious. In larger plants each workman is given a number, which identifies him also on the detail work cards to be discussed later. In some factories each man on entering takes from a checkboard a brass check bearing his number and drops it into a box provided for the purpose. Under other systems he receives his check on leaving the works and deposits it on entering the works again. The timekeeper notes the absentees by means of the checks remaining on the board. Late-comers are noted by the checkboard watchman; so, also, are those leaving early, the latter being passed out on a special card signed by a foreman. Such a system insures an accurate tally of all men entering, and is useful in a very large works, irrespective of other checks which may be employed. Promptness and faithfulness are essential to efficiency, and there is nothing so fatal to the discipline

and the efficient management of a factory as irregular attendance on duty. It should be noted, however, that the checkboard placed at the main entrance of a large works does not insure the prompt arrival of all workmen at their places, and it is often supplemented by other time-recording devices which are placed in the several departments.

2. *Time-recorders.*—In moderate-sized plants the time recorder is much more serviceable than the checkboard. There are many forms of time recorders, but the general principles involved in their use do not differ materially. Usually each workman is provided with a card similar to Figure 7 (page 80). On entering the works he takes his card, which bears his name and number, inserts it in a slot in the recorder and presses a button, or lever, which causes the mechanism to record the time at which this operation is performed, as illustrated in Figure 7. When he leaves the works the operation is repeated, the clock being adjusted in the meantime to print the time in the "out" column. The card is therefore a complete record of the time during which the workman has been in the works, but does not necessarily record his productive time unless used specifically for such a purpose. Such clocks may be placed on the several floors so that, if desired, they may be used also for dating work cards. Where the clock is used simply to check the men coming in and going out, a card of the form illustrated in Figure 7 is usually employed. In some cases two sets, of different col-

ors, are employed, one being in use on Monday, Wednesday and Friday and kept in the office on alternate days for posting. The other set is used on

WEEK ENDING MAY 30 192

No. 154

NAME

W. H. Harding

DAY	MORNING		AFTERNOON		EXTRA		
	IN	OUT	IN	OUT	IN	OUT	
MON.	M 6 55	M 12 01	M 12 56	M 6 01			
TUE.	T 6 59	T 12 05	T 12 57	T 6 11			
WED.	W 6 58	W 12 01	W 12 59	W 3 30			−2½
THU.	T 6 53	T 12 03	T 12 51	T 6 08	T 6 58	T 10 02	+3
FRI.	F 7 30	F 12 04					−5½
SAT.	S 6 57	S 12 08	S 1 01	S 6 09			
SUN.							

TOTAL TIME 55 HRS.

RATE 32½¢ PER HR.

TOTAL WAGES FOR WEEK, $ 17 88

FIGURE 7

the other days in a similar manner. In simpler systems, where the cost keeping is of less importance, the time record is made on a continuous paper ribbon; and, again, in some systems a clock centrally

located is operated by push-buttons which may be variously placed at a distance from the clock.

Methods such as these provide for the accurate recording of the total time worked, but, in general, do not show anything regarding the character of the work performed or the purpose for which it is intended. In the case of certain classes of clerical and administrative employes working at fixed duties and paid by the month, the time-clock record, as noted above, may be sufficient, and in such cases the card shown in Figure 7 may also be used as a pay-roll, as indicated at the bottom of the card, provided, of course, that the clock record is checked up in the manner to be described. But where it is necessary to make accurate distribution of the labor expended, an additional record must be made.

3. *Traveling timekeeper.*—There are two general methods of collecting the time of each man in detail. Under the first method a traveling timekeeper visits each employe daily, having first checked off the absentees of the day before from the checkboard record, if one is in use. From each man he obtains a record in detail of his work of the previous day—that is, the number of hours expended on each order number. He records in a book the data so obtained, with a memorandum of the class of work or the machine used, and this serves as the basis of charging up the work to the several orders. Such methods are not to be recommended even in the simple case where every man is on daywork. The busy workman is not likely

to make a record at the time the work is performed and his memory is unreliable when he is called on to record the result of the previous day's duties. The clerical work involved is also considerable, and where a large number of men are employed, and especially where the number of shop orders is great, the time book becomes bulky and complex. When the piece-work plan and the more complex premium and bonus system are used, the traveling timekeeper is inadequate, especially if the number of men employed is large.

4. *Job tickets.*—The more modern and also more accurate method of obtaining time distribution is by means of the work card, or "job ticket," as it is often called. There are three types of these tickets which may be noted:

(a) The work card which is attached to the material when it is issued from the storeroom, and which accompanies it thru the shop, the labor of each man who works upon it being recorded as the material progresses.

(b) The work card which is issued to the individual workman daily by the foreman, and on which the workman records the details of his day's work, giving the order number of each job worked on and the time expended upon it.

(c) The individual-job work card issued by the foreman to the workman for each and every job worked on, and on which is recorded the order number and the time expended on one job only.

The limitations of the first type are obvious. In small shops and for certain classes of work it is applicable, but the constant handling of such cards, in a machine shop, for instance, reduces them in a short time to an unintelligible state. Furthermore, the accuracy of the information thus gained is open

DAILY-TIME TICKET

DATE May 1 192—

WORKMAN'S NO. 36 NAME John Smith

JOB NO.	OPERATION	HOURS	RATE	VALUE	
60	Boring	2	.30		60
175	"	3½	"	1	05
254	"	2½	"		75
75	"	2	"		60
			TOTAL	3	00

FOREMAN Wm Jones

Figure 8

to question and it cannot be recorded conveniently until the job is finished; as a result, therefore, there is a lag in the cost records.

The second form of job ticket is shown in Figure 8, above. Upon this ticket provision is made for noting the time expended on the several orders on which the man has worked during the day. Its sole advantage, therefore, over the traveling-timekeeper

method is that the workman is provided with a systematic method of keeping his own time, but it is open to the same criticism of possible inaccuracy as is the timekeeper system. The second form of card is superior to the first, however, since by means of it returns are made daily, and can be checked more readily by the foreman as they are turned in. These returns can also be used to check up the time recorded by the workman on the time clock or checkboard at the shop entrance. The work of posting up the time charges against the several order numbers is cumbersome, however, if there are many such orders in progress; moreover, they are awkward to analyze for the purpose of making cost reports, because the work on several order numbers may be placed on the same job ticket, as shown in Figure 8. It is difficult, also, to trace disputed items after the job tickets have been posted, since they cannot be filed under separate order numbers.

The third type of ticket is by far the most flexible and the most commonly used. As before stated, a separate ticket is issued to each man for each job worked on each day and all tickets are collected daily. Figure 9, opposite, illustrates such a card arranged for dayworkers. It bears the workman's name and number, the date, and the order number of the job. It may be arranged, as in Figure 9, so that the workman may check off not only the elapsed time expended on the job. but also the character of the operation involved. Thus the need of any writ-

DAYWORKER'S CARD

MAN'S NO.	DEPT.	DATE	ORDER NO.

DRAW NO.	PATT. OR PRT. NO.	NO. PIECES	O.T.	HOURS	RATE	VALUE

DESCRIPTION OF WORK

6	½	7	½	8	½	9	½	10	½	11	½	12 1	½	2	½
3	½	4	½	5	½	6	½	7	½	8	½	9	½	10	½

APPROVED ________________________________

FOREMAN

1	ASSEMBLING
2	BALANCING
3	BANDING
4	BUILD. UP
5	BURR. SEGMENTS
6	CHIPPING
7	CLOSING UP
8	FITTING
9	HOT PRESS
10	PRESS ON COM.
11	PRESS ON COLL.
12	RIVETING
13	SOLDERING
14	TAKING DOWN
15	PAINTING
16	CONNECTING
17	INSULATING

FIGURE 9

PIECEWORKER'S CARD

MAN'S NO.	DEPT.	DATE	ORDER NO.

MAN'S NAME

DRAW NO.	PATT. OR PRT. NO.	OPERATION NO.	HRS.	PIECES	PRICE	VALUE
					PER	
					PER	
					PER	
					PER	
					PER	

6	½	7	½	8	½	9	½	10	½	11	½	12 1	½	2	½
3	½	4	½	5	½	6	½	7	½	8	½	9	½	10	½

APPROVED ________________________________

FOREMAN

1	ASSEMBLING
2	BALANCING
3	BANDING
4	BUILD. UP
5	BURR. SEGMENTS
6	CHIPPING
7	CLOSING UP
8	FITTING
9	HOT PRESS
10	PRESS ON COM.
11	PRESS ON COLL.
12	RIVETING
13	SOLDERING
14	TAKING DOWN
15	PAINTING
16	CONNECTING
17	INSULATING

FIGURE 10

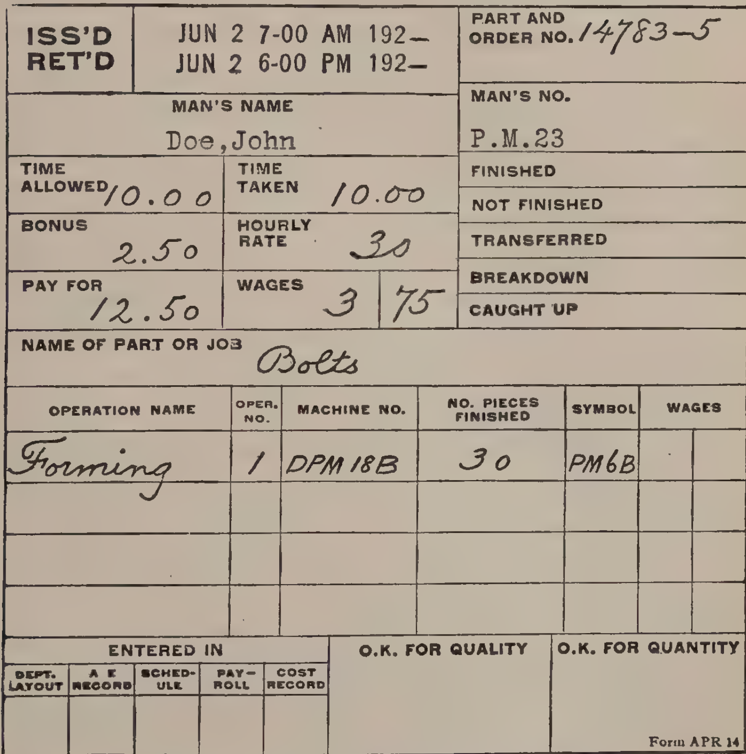
ing on the part of the workman is obviated and by so doing much time is saved and mistakes due to illegibility are avoided.

Figure 10 (page 85) shows a similar card arranged for pieceworkers. In addition to the general information given on the dayworker's card this card records the number of pieces, the rate per piece, and also the elapsed time. This last has nothing to do with the workman's pay, but is recorded so as to check up the total time against the clock record, for reasons already noted.

Figure 11, opposite, illustrates a work card which has been used by Mr. Gantt for recording bonus time. It records the time allowed, the time actually taken, the bonus and the total time for which the payment is to be made. Provision is also made for the inspector's approval for both quality and quantity.

All of these cards, as will be noted, record full information regarding the job. They all record the workman's name and number, the order number, the part and drawing numbers, as well as full information regarding the operation performed. The operation and its cost are therefore identified fully with the order number, and full information is recorded for statistical use, if this be desired. The forms of job ticket shown in Figures 9, 10 and 11 lend themselves admirably to statistical purposes, for, since only one order number is recorded on each ticket, the sorting and arranging of these tickets by order number and classes is an easy matter.

5. *Other time-recording devices.*—While the job tickets discussed in the preceding section assist greatly in securing accurate time records, it is clear



ISS'D RET'D	JUN 2 7-00 AM 192– JUN 2 6-00 PM 192–	PART AND ORDER NO. 14783–5
MAN'S NAME Doe, John		MAN'S NO. P.M.23
TIME ALLOWED 10.00	TIME TAKEN 10.00	FINISHED NOT FINISHED
BONUS 2.50	HOURLY RATE 30	TRANSFERRED
PAY FOR 12.50	WAGES 3 75	BREAKDOWN CAUGHT UP
NAME OF PART OR JOB Bolts		

OPERATION NAME	OPER. NO.	MACHINE NO.	NO. PIECES FINISHED	SYMBOL	WAGES	
Forming	1	DPM 18B	30	PM6B		

ENTERED IN					O.K. FOR QUALITY	O.K. FOR QUANTITY
DEPT. LAYOUT	A E RECORD	SCHEDULE	PAY-ROLL	COST RECORD		
						Form APR 14

Figure 11. Work Card for Bonus Workers

that they are not proof against errors, especially in the hands of ignorant or careless workmen. For this reason, provision is sometimes made for stamping the time of starting and the time of finishing each job by means of a time-clock instead of having the

workman check them off by hand. This is illustrated in Figure 11, on the upper left side of the card. In such cases the time of starting the work is stamped on the card by the assistant to the foreman, and when the operation is completed the workman presents the card to the assistant, who stamps the time of completion and issues a new card with a new starting time stamped thereon. Another device, a form of time-clock which prints elapsed time, has also been used to facilitate the operation of time recording. There are a number of such devices now in use, some of which have proved to be very practical. These differing methods in no way affect the essential principles involved, being of the nature of mechanical aids only.

One fundamental principle should be carefully observed, whatever may be the system of time recording, namely: Every piece of direct production should have a distinctive order number assigned to it, and every kind of indirect work should have a permanent or standing-order number which remains fixed until changed by the cost keeper. No work of any kind should be performed that is not authorized by the proper officials and covered by a production order or a standing-order number.

6. *Summarizing time and labor returns.*—All work cards are usually approved by the proper foremen and are then forwarded to the timekeeper, who checks the daily total of each man's card with his clock or check-board record. These should of course

agree. If the worker is on day pay this total forms the basis of his daily wage. If, however, he is on piece or premium work, the proper additional data must be added to the pay-roll, tho the total time recorded must check as before. The exact method of recording premium and bonus earnings will necessarily vary with the character of the work and the pay system in use, but in any case there should be an exact balance between the pay-roll and the labor values recorded on the cost sheets. As has been shown, it may not always be necessary for all men to hand in a work card, because their duties are simple and constant, and a record of the time expended is sufficient to evaluate their services and distribute their cost. As a general principle, however, it is good policy to have every man whose name is on the weekly pay-roll hand in a work card, so that the two systems of recording time will exactly balance.

After the timekeeper has taken the data for the pay-roll, the work cards are forwarded to the cost keeper, who sorts the cards by order numbers and charges up on the cost ledger the costs on each card against the order number which it bears. This work is greatly facilitated by making the work cards of different colors so that they can be sorted rapidly. The charges made to the several order numbers are summarized periodically and carried forward to the general ledger in condensed form. They form the basis of various kinds of reports, which will be discussed in a succeeding chapter. These detail and

summarized time charges contain valuable information that can be compiled and compared and the information thus gained may be of great benefit to the manufacturing superintendent. The general method of analyzing this information and presenting it in the form of reports is discussed in the volume on "Plant Management." The methods of recording time, discussed in the preceding section, are comprehensive, and applicable even in very complex manufacturing. It will be clear, also, that as the enterprise considered approaches more closely the continuous type of manufacturing, the methods for recording the time expended become correspondingly simpler.

7. *Other items of labor costs.*—In the foregoing discussion it has been assumed that there is no time lost between jobs and that the time of finishing one job is the time of beginning another. Such close connection is not always made, however, and if much time intervenes between jobs, care should be taken that such time is not charged against production orders, tho this actually is often done; in fact, such procedure is even advocated by some writers. Certainly such loose time accounting will vitiate any system of cost accounting; lost time of this nature should be charged to an expense account provided for that purpose. Other items of lost time, such as time paid for without return, as in cases of accident, temporary stopping of machinery, etc., should be similarly handled. A careful record should be kept

of these items and they should be analyzed with a view to minimizing such losses. Many managers would be surprised to know how much time is lost in this manner simply because it is never brought before them in a collected form.

It might be said in passing that time losses between jobs can be greatly lessened by planning the work in advance, a procedure that is entirely in keeping with modern ideas of management. A bricklayer cannot lay bricks unless he has them at hand. Even when the workman is on piecework, and is the apparent loser thru lost time, it should be remembered that the factory loses by any reduction in output, since profits depend on quantity produced, as much as they do on profits per piece. Every effort should be made, therefore, to have work moved from operation to operation promptly and quickly, and all work, if possible, should be studied in advance, to insure the best and most direct sequence of operations.

It should be noted, also, that the discussion of time-saving applies not only to direct labor but even more particularly to indirect labor. As will be shown later, the indirect labor may be, and often is, a large part of the wage cost. The time-saving principles and time-recording methods that are found useful in connection with the man at the machine, will also be found advantageous in connection with the clerk in the office or the helper in the yard.

REVIEW

What kind of work card would you lay out for (1) daywork; (2) piecework; (3) premium or bonus work?

What system of time recording would you adopt in a factory employing common labor of a low mental type?

What do you understand by the term "job ticket"?

How many types of job tickets are there, and what are the advantages and disadvantages of each type?

Of what importance is it to know the causes of idle time?

What are the various purposes of collected time cards?

CHAPTER VII

EXPENSE OR BURDEN

1. *Character of expense.*—It was shown in Chapter II that many items of labor and material that are essential to the operation of the enterprise cannot be directly connected with any particular piece of product. An examination of Figure 2 (page 21), and also of the expense accounts listed in Section 1, Chapter IV, will make this fact clearer. It holds true of practically all enterprises of any magnitude, and follows directly as a result of division of labor. It will be remembered, also (see Section 8, Chapter III), that it is always desirable to segregate the shop costs from the selling and other costs, if for no other reason than to render it possible to hold the proper individuals responsible for these costs. Under the general name of "factory expense," or "burden," is included, therefore, all labor, all material, and all other items of manufacturing cost that cannot be charged directly to some particular piece of production. It will be noted that while, in general, all such material and labor are of the indirect kind, certain expense material may go directly into the product. Thus, nails, screws, glue, and similar items, may be used in such small quantities on each piece of prod-

uct as to make direct accounting difficult, if not impossible. Items of this kind are therefore carried to an expense acount and distributed with other expense items.

The general character of selling expense and office, or administrative, expense is shown in Section 1, Chapter IV, and it should again be carefully noted that, while these two classes of expense are often gathered up under the one head "general expense," they are esentially independent quantities. In fact, if the selling expense is of any consequence it should be segregated. Moreover, as will be shown, it is often desirable, as the enterprise increases in size, to subdivide shop, administrative and selling expense so as to hold each *department* of these activities responsible for its own just share of the expenditures.

Many items of expense do not naturally attach themselves quantitatively to machines or processes, but gather like clouds, of greater or less density, over the entire enterprise. There is no great difficulty, as has been shown, in finding the cost of the direct labor and the direct material that enter into a product. Nor is it a matter of great difficulty to classify the many items entering into the expense and to find the total amount of such classes for any given length of time. The charging off of this total expense over the total product for any particular period of time presents, also, a simple problem. But it is exceedingly difficult, except in very simple cases, to assign

to each shop order its own share of expense with any great degree of accuracy. The principal problem of cost finding is so to assign the expense, or burden, that each article shall bear its own share, and only its own share. This problem may be made a little clearer by a further consideration of the characteristics of expense.

2. *Expense fluctuation with volume of business.*—An examination of the expense items of any enterprise will show that while some are fairly constant in amount, others go up and down with the volume of the business, tho according to different laws. In a general way the items that are constant include all expense incident to the existence of the enterprise, irrespective of productive operations. Thus, such items as the rent, taxes, insurance, and depreciation of buildings do not vary materially, whether the enterprise is active or not; or, if they do vary, the change is likely to be occasional and by large amounts. Otherwise, they remain fairly fixed for long periods. Such expense, furthermore, can never become zero, no matter what the volume of business may be. The salaries of permanent officials are of this character and are not affected, in general, by changes in the volume of business. Depreciation, it should be noted, may be even greater when the factory is idle than when it is in operation, since then many ordinary measures for minimizing depreciation are not active.

Other items of expense, on the other hand, are af-

fected quickly by changes in the volume of business. Thus, clerical help, indirect labor and operating supplies are directly affected by such changes, moving up and down as the volume varies—tho not, as a rule, in direct proportion to such variations. For instance, it requires a definite minimum amount of oil to lubricate the shafting of a factory, whether any machines are in operation or not, and any further amount of oil that may be necessary is obviously dependent upon the volume of work passing thru the shop. This relation is usually so complex that it cannot be expressed in terms of any fixed factor of production. In general, however, the relation between the amount of oil used and the volume of output may be expressed thus

$$Q = K + f\ (V)$$

where Q = the quantity of oil, K = a constant, and $f\ (V)$ = some function of the volume of work. Many other expense items, such as power, light, and some kinds of indirect labor, are of this general character.

It is important to notice, however, that from this it is clear that profits do not vary proportionally with the volume of business. Half-volume does not mean half-profits, since there is always an irreducible minimum of expense; and if this irreducible minimum is high compared with the variable expenses due to the activities of the business, a comparatively small decrease in business may eliminate all profits, if it does not actually cause a deficit.

3. *Variations of expense due to time.*—Expense, again may vary according to time. Thus, a large amount of coal may be purchased, either to take advantage of the market, or to provide for emergencies; but the use of this coal may extend over weeks or even months. The demand for certain kinds of expense material may vary with the seasons. Thus more coal is needed in the winter season, while ice is needed particularly in the summer. Extensive repairs may be made to buildings or machinery because of the wear and tear incident to the work of previous weeks or months. These and similar expenses may fluctuate greatly and with little reference to the volume of business. Yet, clearly, it would not be fair to current production to charge off such heavy expenses against it, thus unduly favoring either future or past production. Such expenses must be averaged over a reasonable period of time, even tho the method of fixing such an average may be more or less arbitrary. Of course, when the products of the factory are seasonable—that is, when some kinds are made only in the winter, and other kinds only in the summer—there may be expenses that can be allocated justly on a seasonable basis, but this case is uncommon.

Expense must often be charged off by an average rate, for still other reasons. Once a month is about as often as it is convenient or desirable to close the general books and summarize all accounts, direct and indirect. If it were possible to start each job on

the first day of the month and finish it on the last day, it would be possible to allocate to each job, with fair accuracy, a proper and fair share of the total monthly expense. Such conditions, as a matter of fact, are never found, since all work must be started and finished regardless of the day of the month. Expense must, therefore, be allocated on the basis of summarized expense items of the past month, or months, the data for the current month not usually being available.

Some cost accountants prefer to use the expense data of the preceding month only, on the ground that conditions do not change from one month to the next as much as they do during a period of several months. If this is done, however, special attention must be paid to large periodic expenses which are properly chargeable over a considerable period of time. This difficulty of determining with accuracy the expense items that have been incurred during the time a particular piece of work has been in process of production, and the expenses which are logically an integral part of the cost of producing that work, should be carefully considered, for the problem that it presents involves factors that prevent any cost system from being very accurate.

4. *Expense variation with character and size of work.*—The amount of expense which any part should bear will also vary with the character of the operations performed upon it. Thus, in a plant manufacturing electrical appliances some parts must

be dipped in insulating material and perhaps baked. Other parts will not require such treatment and, clearly, they should not, to be exact, bear any of the expense of the insulating department. In factories producing different lines and involving both intermittent and continuous manufacturing processes, such conditions are often met, and they sometimes offer a difficult problem in cost finding.

The amount of burden that a part is justly entitled to bear may vary also with its size or weight. Strictly speaking, small parts should not bear any part of the expense due to crane service and large equipment in general. Theoretically at least, a large casting should bear a greater share of the repairs to the cupola than should be charged against a small one.

This problem is a difficult one in factories producing lines of goods that have a large range in size, where competition is carried on with other factories each one of which produces only a small part of the range. Other things being equal, a factory producing a full line of electric motors ranging from one-quarter horsepower to 5,000 horsepower would have difficulty in competing with a company producing motors from one-quarter horsepower to ten horsepower, unless special care were taken to prevent the larger costs due to the larger product from being unjustly charged against the smaller product that does not require the larger equipment for its production. To differentiate such charges is, however, often a

difficult matter, but the difficulty can be lessened by careful departmentization which will bring parts of like kind and equal size under the same departmental organization.

5. *Clerical and selling expenses.*—These problems and difficulties are common to office and shop alike. Clerical work is, in general, difficult of exact allocation, particularly where the product is varied and complex. It may, and usually does, involve more expense to do the clerical work connected with making a small, complicated machine than it does to take care of the clerical work connected with a much larger and costlier product. This is particularly true where costs are required in detail, since, in that case, the number of production orders may be very great for the small, complex machine as compared with the large, simple machine. For the same reasons, the cost of superintending the production of the small machine and of collecting the labor and material costs may be excessive as compared with the case of the large machine.

What is true of the factory office is obviously true also of the general office and the sales office, the expenses of these last departments being particularly vague, so far as allocation to any one job is concerned. The cost, for instance, of doing the business connected with selling standard product, which is well-established in the market and practically sells itself, is much less in proportion than that involved in selling special sizes or types or in disposing of prod-

uct for which a field must be created. Yet, practically, it is often difficult to segregate these expenses. This is markedly true of the work of the salesman, who frequently labors in vain, or whose reward comes in the form of sales, the "missionary" work for which was performed a long time before.

6. *Two purposes of expense distribution.*—Aside from the general characteristics of expense which have just been discussed, each item of expense has special characteristics that must be considered in connection with its distribution against production. Certain expenses such as fuel, oil and certain kinds of indirect labor, are clearly chargeable against manufacturing expense, while other items are just as clearly chargeable against general expense or selling expense. In segregating and classifying expense it should be remembered that the object in view is twofold:

(a) To allocate each item as fairly and as accurately as is possible or desirable.

(b) To record and summarize each class of expense in such detail as will make possible its analysis and clearly show its content.

The first requirement involves a consideration of methods of distributing expense, which will be discussed in Chapter X; while the second requirement governs the detail in which any item of expense shall be collected and recorded. This last requirement will now be considered briefly.

7. *Classifying expense factors.*—As noted in Sec-

tion 8, Chapter III, clear-cut distinction should be made, if possible, between manufacturing expense and general expense. This is necessary, if for no other reason than to fix responsibility for such expenditures. The manufacturing superintendent should be held strictly responsible for the expenses that are a legitimate part of production, and for those expenses only. The general manager should assume responsibility for the general expenses which are incurred by the managing and accounting branches of the business. In small enterprises the sales expenses are often included in the general expense, but usually it is considered better to collect the sales expenses separately, so as to be able to hold the sales manager responsible for his own expenditures. When this responsibility has been determined, however, there is no gain in keeping these expenses separated, and for convenience they are generally merged and distributed against the product as one expense.

It is not always possible to make an absolute division of expense between these two classes, because the organizations of industrial enterprises differ so widely. Thus the president may also be the sales manager, and the duties of other officials may include supervision of the manufacturing and general activities of the business. However, even in such cases a proportional division of their salaries can always be made that will be equitable to all concerned.

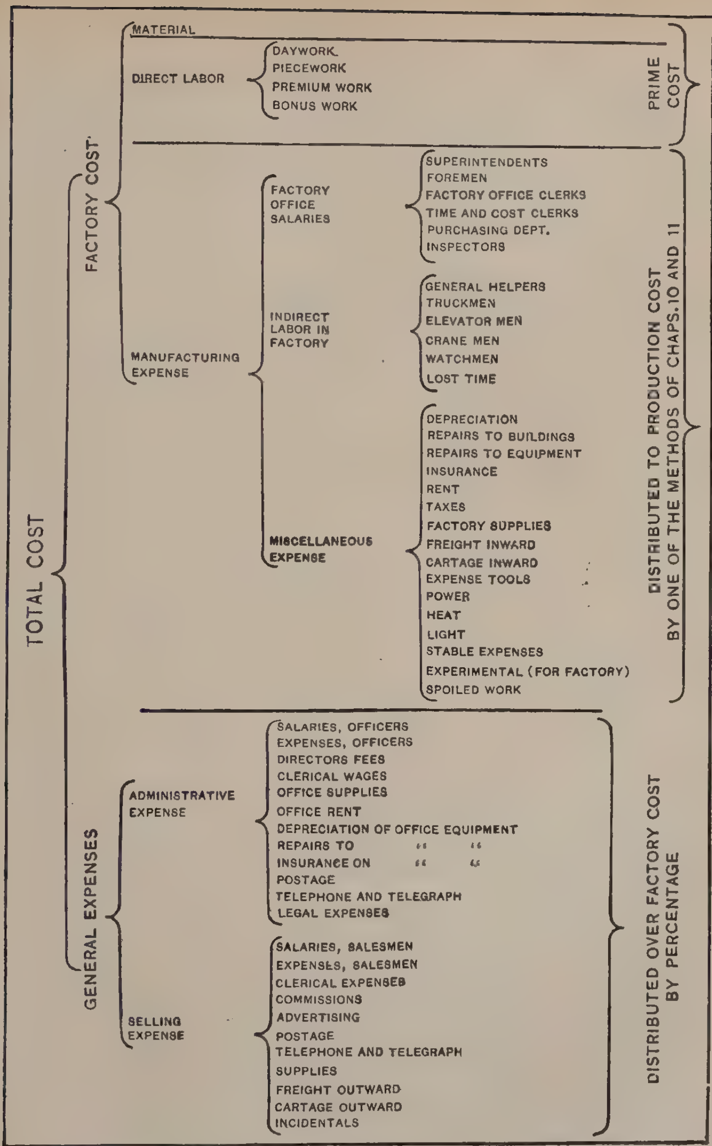


Figure 12. Distribution of Production and Selling Costs

In Figure 12, page 103, is shown a classified analysis of the cost of production, including selling costs, as it occurs in an average manufacturing plant. Only typical items are shown, since the detail in which it is necessary or desirable to take account of expense depends entirely upon the industry and the size of the enterprise; one very large factory in this country has no less than 130 expense accounts. As the size of an enterprise increases, all items of expense assume greater importance and segregation becomes more and more imperative. Each factory expense account should be designated by some number or symbol similar to those used for production accounts, as explained in Chapter IV, and no charge should be made against any account unless it is authorized by a written order from the proper official. The classification given in Figure 12 is in general accord with the practice of skilled accountants and cost men. To distribute logically the great majority of these accounts among manufacturing expense, general office expense and selling expense, is not, as a rule, difficult in any particular case; but there are a few items on which all cost keepers and accountants are not agreed, concerning which more detailed discussion may be helpful. These are rent, interest, taxes, insurance, defective material and spoiled work, lost time, engineering and development, repairs and improvements, patterns, drawings and small tools, and depreciation.

8. *Theoretical consideration of interest and rent.—*

To the accountant rent and interest are identical, since rent is money paid to a capitalist for the use of buildings or equipment, while interest is money paid for the use of capital. There is a considerable difference of opinion, however, among accountants and cost-finding experts as to the way in which these items should be cared for in the accounts. Some authorities would not include either of them in the details of factory costs but would add them to the total factory costs, carrying the transaction in the general ledger. Others would include all such items in the factory costs as a true part of the cost of production. Some would include rent but not interest as a part of factory costs, but this view is not reasonable, considering the similarity of the two items.

The argument advanced by those who would exclude rent and interest from factory cost is that these items being attributes of capital are in the nature of a division of profits, and should therefore be accounted for by deducting them from profits. The argument is also advanced that the manner in which the capital is obtained can in no way affect the actual cost of manufacture. It is urged that the manufacturer may provide all of the capital, or that he may borrow a part of it from others, dividing a part of the profits of the enterprise with these other capitalists, in the form of rent or interest, but that no part of these items is a logical part of the costs.

Now, it is true that to the man who lends facilities or money, rent and interest are in the nature of pro-

fit, but to the manufacturer who has borrowed these facilities or money, rent and interest are simply debts that must be paid before he can obtain a profit. So far as simply securing this profit is concerned, it makes no real difference to him whether these items are distributed in the costs or are added to the costs before fixing the selling price. If the clerical work is accurately done the result will be exactly the same in either case.

9. *Practical consideration of interest and rent.*—It should be remembered, however, that the purpose of cost finding is not to decide theoretical points in economics, but to allocate all expenditures so that the cost of each article shall be segregated as far as possible, and so that it will be possible to tell which lines of production are paying and which are not. If, now, the manufacturer is producing his goods with borrowed money, on machinery of varying value, housed in buildings of varying cost, it is obvious that, unless rent and interest are distributed against the product in proportion to the use made of the facilities of the plant, he can form no definite idea as to the comparative profit-earning values of his several lines of product. There is just the same reason, in fact, for distinguishing, in these matters, between different departments or machines of the same factory, as there is in distinguishing between different factories owned by the same man, tho he may have borrowed from the same source all the money with which to erect his different factories. In the case of a simple continuous

industry it is not necessary, of course, to distinguish so finely in these matters, since each unit of product bears the same amount of each kind of expense.

It will be noted, however, that when money is borrowed for commercial purposes, and not for investment, or use in manufacturing facilities, the status of interest paid upon such indebtedness is different. Thus, if the commercial department borrows money so as to be able to extend credit to customers whose accounts are due, or if money is borrowed at a low rate to discount purchase invoices at a higher rate, such interest and discounts have no relation to the cost of production, but belong to the general, or sales, accounts and should be considered accordingly.

10. *Interest on owned capital.*—The case where the manufacturer owns his plant would seem, at first sight, to be somewhat different; for here, apparently, he does not need to include interest charges on his investment, in computing either his factory cost or his total cost. A brief reflection, however, will show that the case referred to is only seemingly different. If the owner of an enterprise cannot make a profit over and above interest charges on his investment, it would be easier for him to lend his money to some other person, who would pay him such interest and assume all the risks and responsibilities of the business. The owner could then work for some one else and earn a salary. These facts would seem to indicate that the salary of an operating owner should also be considered a part of the cost of production

and should not come out of profits. It is clear, of course, that the manufacturer who owns his plants has a great advantage over one who rents his plants, since the latter must make a minimum profit to meet his interest charges, while the former is not necessarily in any danger, even tho his investment does not pay him the market rates of interest. From the standpoint of practical cost finding it would seem clear that a reasonable allowance for interest on the investment should be distributed in the factory costs, if for no other purpose than to determine the comparative profit-earning capacity of the several lines of output.

This general principle was approved by a committee on uniform cost accounting of the National Machine Tool Builders' Association, which recommended that interest at the rate of at least five per cent on the investment be distributed in the burden, where the manufacturer owns his own plant. This committee recommended also that where the manufacturer rented his facilities, or borrowed his capital, the rent and interest should be included in the factory costs, in accordance with the arguments presented in Section 9 of this chapter.

These views, as before noted, are not held by all cost experts and accountants. Tho the practice of including interest and rent in costs is now common, it is argued that the inclusion of these items in the factory costs may raise the total costs above the market price, and that it is better to defer such

charges till the end of the year, or such other period when the general books are closed, and then to make whatever allowance is desirable. In reply to this argument it may be said that costs are costs, and that it is far better and safer to determine them as accurately as possible, and then, if they cannot meet the market prices, proceed to reduce them by economies, or better methods, till the desired margin is secured. A careful comparison of the earnings of each tool with the interest on the investment involved, would often lead to the discarding of the tool, a change in the product, or a higher charge for the services of the tool.

REVIEW

How will the individual items of expense burden shown in Figure 12 vary on account of the following factors: Volume; Time; Character and size of work done?

Why should interest on owned capital be charged as a part of manufacturing expense? What rate would you select?

What is the purpose of expense distribution?

Is rent properly included as an item of manufacturing expense? Give reasons.

CHAPTER VIII

EXPENSE OR BURDEN (*Continued*)

1. *Taxes and insurance.*—These arguments regarding interest and rent are applicable as well, in their entirety, to taxes and insurance, which are also sometimes considered as incidents of capital, and are therefore included in the general costs. Accurately proportional allocation of costs requires that they also be distributed in the manufacturing expense. This proportional allocation should take account not only of the varying value of buildings and equipment, but also, in cases where the material is costly, of the value of the material in process in each department.

Taxes and insurance are excellent examples of periodic expenses which really are chargeable over the product turned out during the particular period covered by the payment. These items, being usually paid in advance, are most logically cared for by carrying them to a "suspense account" from which they can be charged off monthly into the costs. Other expense items, such as coal, for example, can be conveniently handled in a similar manner.

2. *Defective material and spoiled work.*—It would seem logical, at first sight, to charge the cost of defective castings and spoiled work to the order num-

ber of the job in which these occur. Where the defective or spoiled part is one of a very large lot this procedure would be proper; or if the work is so unusually difficult that bad castings or defective workmanship are likely to occur to a greater extent than in the ordinary run of work, it is clear that the extra cost so incurred should be charged to the product or class of work concerned, since it is, in general, a more costly line of goods to produce.

The cost of an occasional bad casting or a spoiled part should not, however, be charged against the particular job in which it occurs. Such items of cost should be carried to a separate account (see Figure 12, page 103), and charged off in the manufacturing expense, for thus it will be possible to distribute these losses as a light tax over the entire product. If the cost of occasional misfortunes is charged to the individual jobs in which they occur, some jobs will be penalized to such a degree as to raise their cost out of all proportion, and it will be practically impossible to determine what the true cost should be. Clearly, also, all such costs should be entered in the records as separate items, so that no confusion may arise in estimating upon new work, in which such occasional losses may not occur. All such losses should be reported on a special form, and should also come under the eye of the superintendent. The report should give full information regarding the defective material or the spoiled work, the names of all men concerned, the reason for the loss, etc. Further-

more, the total of the account to which these items are carried should be carefully scanned, since it is an index of the efficiency of certain phases of production.

Defective purchased material should, of course, be carried in a separate account, if for no other reason than to fix responsibility for the entailed losses. Such losses, however, are also manufacturing expenses and should be distributed accordingly.

3. *Lost time.*—In every enterprise there is usually a considerable amount of time for which payment is made but for which no return is received in productive effort. Thus, there may be considerable time lost by the stopping of machinery for short spaces of time, temporary extinguishment of the lights, cleaning of machinery, and in waiting for material, tools or information. It is clear that, in general, such costs should not be allocated to particular jobs, if the cost records are to serve as a means of predicting future performance. Furthermore, lost time, like spoiled work, is a measure of efficiency in management. Much of the lost time in the majority of plants could be saved by careful planning of the work and careful examination and repair of machinery in advance. The general principle of planning work and repairs in advance is one of the cardinal principles of modern industrial engineering, and is well worth the consideration of all managers. (See also Section 7, Chapter VI.)

Lost time, like spoiled work, should be carried to a

separate account (see Figure 12) and distributed in the expense. This also gives the management an opportunity to check up the total of such time losses and to exercise supervision over it in a manner not attainable if such losses are buried in the job costs.

4. *Engineering and development.*—In many enterprises there are certain expenditures the distribution of which will vary with conditions. Engineering and similar work, for instance, may be for one of three purposes:

(a) For securing specific contracts

(b) For specific contracts already secured

(c) For the production of standard product, either for orders on hand, or to be received.

Engineering and other preliminary work performed for the express purpose of securing contracts is purely commercial in character and should be charged to selling expense. Work of this kind may include designs, blue-prints and estimates of considerable cost. Clearly, the manufacturing department should not bear an expense of this nature, often very heavy, with which it is in no way concerned.

Should the contract be secured, and should the preliminary work be used in the actual construction, the cost of the preliminary work may be divided between selling expense and manufacturing expense; or, in some cases, it may justifiably be charged entirely to manufacturing. This should never be done, however, if the contract for which the preliminary work was done is not secured. In that case it is a

selling expense, pure and simple, and if entered in the selling expenses it has some significance; on the other hand, it is not only poor accounting to charge such preliminary work to manufacturing expense, but it is poor management, generally, because such procedure results in general confusion in the manufacturing expense accounts.

In the case of specific contracts for products which are not likely to be built a second time, it is obvious that, as far as possible, all cost pertaining to the product should be charged against it. All engineering, and all special experimental work, special tools, etc., then become direct costs of production, chargeable against the work with which they are connected. Some manufacturers consider all drawings and patterns as assets and charge their value to capital account. In the case of special contracts which are not likely to be repeated such a procedure is seldom justifiable. It is better and safer to charge all expenditures made on special product to the cost of that product if any doubt exists regarding the special facilities so provided being used elsewhere.

Engineering and development work done on standard product which is passing thru the factory in quantity is of a different character and cannot be allocated to jobs; it must be treated as manufacturing expense. It is, of course, often possible to segregate such expenses where they are incurred for specific lines of product, and charge them off against those particular lines; but in complex cases even this may

be difficult. Thus, experimental work conducted to perfect the theory of the design of electric transformers would be applicable to all sizes of transformers but not applicable to electric generators. Yet it would be difficult in a medium-sized shop to allocate this expense solely to transformers, and it would be still more difficult to make each size of transformers bear its proportional share of this burden.

Engineering and experimental work that has for its purpose the development of better manufacturing methods is clearly also a manufacturing expense; but similar work conducted for the development of new lines of product is somewhat different in character. Clearly, also, such work is not chargeable to selling expense. A good way of handling expenditures for new development is to carry them to a development, or suspense, account until it is decided whether or not the line of product under consideration will be built. If it is decided to produce the line of goods this preliminary expense can be charged off against the line over an estimated quantity of product. Such a method of distribution must, of course, be approximate, but, nevertheless, it is much more accurate than charging such expense to other lines of product. If this method is not feasible or desirable, the development account must be closed into the factory expense and distributed by whatever method is in use. If it is decided not to manufacture the line of goods, the development cost should be charged off in the general expense. In any case, great care should be

exercised in carrying development work as an asset, as is sometimes done. If so treated, and if the asset be at all of a perishable character—whether drawings, machines or engineering data—the development cost should be depreciated as rapidly as possible by charging into current costs.

5. *Patterns, drawings and small tools.*—The problem of patterns and drawings is very similar, in some respects, to that of engineering and experimental work. It is the practice of some manufacturers to carry patterns and drawings as an asset, when they are used continuously in production. Great care should be taken in doing this. At best, patterns are short-lived when used; if not used they soon become valueless. Any one who has ever critically examined an old pattern storage knows how useless are most of the patterns found in such places. Wherever patterns or drawings are made for specific jobs, and are not likely to be used elsewhere, they should undoubtedly be charged directly to production. Where patterns are used continuously on standard production they can be charged off, pro rata, over an estimated amount of production. Iron patterns, while they are more durable than patterns made of wood, and while they possess some residual value after they are worn out, should be paid for out of production as quickly as possible; for, tho they may be valuable to the enterprise while it is a "going concern," their value as an asset at a forced sale would be very small.

Drawings, tho undoubtedly a true asset while in

use in a "going concern," are of little market value and should, in any case, be carried at a very low valuation. It is better to charge off such investments by averaging them over an assumed quantity of product. Thus, pattern costs are often absorbed as a charge on foundry cost, and drawings can be absorbed in the manner suggested in the preceding paragraph.

Short-lived, small, loose equipment, in general, and hand tools which wear out rapidly, should either be carried at a very low valuation or be renewed out of revenue and charged off as an expense.

6. *Special apparatus.*—In many manufacturing plants very large sums of money are tied up in jigs, fixtures and special tools. The problem of the extent to which it is justifiable to make such special tools is an interesting one, often involving other factors besides the element of cost, as, for instance, accuracy of form. Generally speaking, however, the making of special machinery should be justifiable from the standpoint of cost of production, but great care should be used in disposing of the cost of such tools. Special tools are, most often, applicable only to the work for which they are made, and, if the line of goods for which they are used should be discontinued, or if the enterprise should go out of business, the value of such equipment is always problematic and in many cases such material is worthless except as scrap. In the case of small equipment, such as jigs and drilling fixtures, it is an unwise policy to

carry their value as an asset. Such value should be considered as a part of the cost of production of the particular line of goods for which the tools have been made, and that value should be distributed over the cost of such goods. This usually involves the creation of a development, or suspense, account covering the original cost of such tools, and an estimate of the probable number of parts to be manufactured, to fully absorb this account.

In the case of large, special machines it may be desirable to consider them as a real asset. But, again, careful judgment should be exercised in such a proceeding. Unless it is clear that such tools are likely to outlive their usefulness by the natural processes of wear and tear, rather than by obsolescence, they should be liberally depreciated at inventory time, to a point where their loss would not be a serious factor. To any one familiar with the collection of old special tools to be found in any factory operating on mass production, the wisdom of such procedure will be obvious. It is essential, therefore, either to bury the cost of special tools in the cost of production, or to see to it that the tools are depreciated to a value that will permit of safely carrying them as an asset. There is no doubt that the neglect of the above principles lies at the root of many industrial failures.

7. *Improvements and repairs.*—A careful distinction should be made between improvements and repairs. Any addition which adds to the earning capacity is obviously an asset and should be so con-

sidered. But even here it is good policy to limit the minimum value of the improvements which are treated as assets, since it is always desirable that charges to capital should consist of important items the value of which, as assets, cannot be questioned. This minimum limit will, of course, vary with the size and the character of the enterprise; in small shops it is perhaps as low as fifty dollars. Any betterments of lesser value should be treated as repairs and carried to the expense account.

When a machine, or other piece of apparatus, is rebuilt or has extensive improvements made upon it, the changes may sometimes be such as will add materially to the producing or earning capacity of the apparatus; they may constitute a true betterment that may be added to the assets. Thus, a machine may be thoroly repaired and, at the same time, equipped with a motor drive. Care should be exercised to make certain in each case that the producing capacity has really been raised before the inventory value of the machine is actually increased.

Repairs of all kinds are in the nature of expense. They are also closely connected with depreciation, which is discussed in Chapter IX. The detail in which repair costs should be collected and recorded will, of course, vary with the enterprise; but there are certain broad classifications that are fundamental and general, as, for instance, repairs to buildings, repairs to machinery, repairs to small tools and loose plant, and repairs to furniture and miscellaneous fix-

tures (see Figure 12, page 103). Each of these general divisions may be, and usually is, subdivided into smaller accounts, the detail often being minute in large plants. In any case, the detail should be such that the responsibility of departments and foremen is clearly shown. This is usually accomplished, as before noted, by a system of standing-order numbers (Section 5, Chapter VI) to which labor and material are charged in the same manner as in the case of productive work.

8. *Inclusion of burden in cost of repairs.*—It is customary in many establishments to consider the material and labor actually used in making repairs as constituting the full cost of such repairs, and no addition is made thereto for other expenses as in the case of a product made for the market. This procedure, however, may in some cases be open to question. If repairs are made on a building, for instance, with material and labor bought directly for the work, it would be reasonable to charge any expense for supervision, purchasing costs, etc., to the cost of the repairs, but since no use is made of the machinery and equipment in making these repairs no other expense should be included in their cost. There are, no doubt, many repairs made on the equipment where the labor of the repair man and the supplies needed are the only expenses involved. But where much supervision is needed and extensive use is made of machinery and floor space to make repairs on equipment, it seems reasonable that such work should bear

its own share of burden just as tho the work were being performed for a customer.

Repairs and replacements may be the accumulated results of ordinary wear and tear, or they may be necessary because of breakage thru carelessness or the overloading of apparatus. They are, therefore, variable in amount and should be averaged over a considerable period of time. Clearly, it is not logical to charge the entire cost of putting a new roof on a building to the particular work passing thru at that time; nor is it reasonable to charge the cupola repairs to the castings made immediately after these repairs are made. In some plants it is customary to charge the cost of minor breakages to the job by which the breakage was occasioned. This is not a good cost-finding policy for even small items. All such costs should go into the manufacturing expense and be distributed over the product.

9. *Plant ledger.*—Besides locating repair and maintenance costs by departments, an individual account should be kept with each building and machine and each group or class of apparatus the components of which are too small to list in individual accounts. Such a record is called a plant ledger. It is most conveniently formed by the card-index method as illustrated in Figure 13. A card is made out for each building or machine, and on this are recorded all repairs and all charges to the piece of apparatus. Such a card, in connection with the proper depreciation of the asset, gives a life history, and is a con-

tinuous inventory, of the asset. The entire plant ledger, therefore, constitutes a continuous inventory

PLANT LEDGER	NO. 48
MACHINE 18"x12' Lathe	LOCATION: FLOOR 1 ROW 6
MAKER Bradford Machine Tool Co.	OUR NO. 48 MAKERS NO. 2146
PURCHASED FROM Prentiss Supply Co.	PURCHASE PRICE $1500
DATE OF PURCHASE 12-6-2-	ESTIMATED LIFE 25 years
NEW OR SECOND HAND new	PROBABLE SELLING VALUE $300
WEIGHT 5020 POUNDS	RATE OF DEPRECIATION 7%

DEPRECIATED VALUE AT END OF YEAR

17	1427	55																			

PLANT-LEDGER CARD (FRONT)

REPAIRS, ADDITIONS AND ALTERATIONS AFFECTING DEPRECIATION							COST OF INSTALLATION
DESCRIPTION	ORDER	DATE	CREDIT		DEBIT		FREIGHT AND CARTAGE $35
Taper attachment	3406	12-8-2-	35	00			FOUNDATION $254.60
							INSTALLATION $65.20

PLANT-LEDGER CARD (REVERSE SIDE)

FIGURE 13

of the equipment and, in conjunction with the stores ledger, the cost ledger and the stock ledger, forms a

complete continuous inventory of all the material assets.

As before noted, only repair items which affect productive capacity are carried to the plant ledger. All others are charged off directly to expense. Small perishable tools, such as saw blades, scrapers, and files, are usually not included in small tool accounts, but are carried under expense supplies. It is a good policy, however, to keep account of the amount of these perishable tools and supplies issued to each workman, as well as a record of all breakage of small tools and equipment. In addition to the information thus obtained concerning the destructive proclivities of the individual workers, the very fact that a record of all breakage is maintained tends to make the men more careful of the more costly equipment.

10. *Sundry expenses.*—In manufacturing establishments, particularly, there are many items of expense which are neither labor nor material, and which are not large enough to warrant the opening of separate accounts in the ledger. The number and amount of such items will naturally vary with the enterprise and its magnitude. Thus, gas and telephone service, which are examples of these items, may be of importance in a large works, but neither one may warrant segregation in a small plant. It is customary to group all such small items into a so-called sundries expense account. Care must be taken, however, that such accounts do not become dumping grounds for all sorts of unauthorized expenditures.

All items entering into such an account should be properly authorized and vouched for, and no item should be entered therein that should logically go into any other account. Many such items will appear in the form of bills payable from outside creditors, but all internal expenditures of this kind should be made on written authorization, and recorded and paid for only when properly vouched for.

11. *Character of general expense.*—It has been shown that general expense is logically divided into administrative expense and selling expense, tho in small enterprises this distinction is not always made. As enterprises grow in magnitude, however, this division becomes more important and these expenses should be carefully separated so that the heads of the departments concerned may be held responsible for their proper shares. In some cases where certain officials have duties that lie in both fields this may mean a more or less arbitrary division of their salaries, but even such an arbitrary division is better than none at all.

The character and classification of the expense items making up administrative and selling expense require little explanation. The classification shown in Figure 12 (page 103) is in accordance with common practice. The detail into which these expenses may be divided will, of course, vary with the enterprise. What may be a small item in one case may be a very large one in another. The majority of these general expenses will appear as bills or vouchers, tho

there may be many items for which production orders may be issued and the costs carried to the cost ledger, and thence to the general accounts.

12. *Cost of welfare work.*—The above methods can, in general, be used to account for all labor, both direct and indirect. The direct and the indirect labor expended in the actual production of goods may not, however, constitute the entire cost of compensation for labor employed. In many shops and factories large sums of money are expended to make the surroundings of the workmen more pleasant and comfortable. Such items of expense as may go into providing superior lighting and sanitary equipment can, of course, be justified on the ground that workmen turn out more and better product in pleasant surroundings than they do under the cheerless conditions common a few years ago; and the interest charges on such expenditures may justly be considered as a manufacturing expense.

But there are other branches of so-called welfare work which are concerned with the development of the workman along broad lines of general culture, and of which provision for general study and social betterment is a good example. Even tho these efforts may be justifiable, viewing the enterprise as a whole, the distribution of such expenditures should be carefully considered. It would not be wise, for instance, to charge the cost of free midday lunches, general reading rooms, summer excursions, and the like, to shop expense, if the manufacturing superin-

tendent could not see that such things really do assist production. This is particularly true since many of the most ambitious efforts along these lines have ended in disastrous failure. Where any question arises about the distribution of such expenditures it may be more expedient to carry them to general expense and hold the general manager, and not the factory manager, responsible for them.

REVIEW

Under what theory is it proper to charge taxes and insurance to expense burden?

What plan would you devise for handling the loss due to defective material?

How should engineering and development expense be distributed in cost accounting?

What is the asset value of patterns, drawings and small tools?

If the fulfilment of a contract required the purchase and installation of an expensive special machine, how should the cost thereof be treated in the accounts?

What is the correct basis for the distribution of the cost of repairs and improvements? Have these expenses any asset value?

CHAPTER IX

DEPRECIATION[1]

1. *General theory.*—In all industrial enterprises there are some assets which are fairly stable in character and which either do not change in value, or, if they change, do so only by degrees. Thus, the purchasing power of cash may increase or decrease but in either case it will do so slowly. The value of real estate may appreciate or depreciate but this change will also be comparatively slow in most cases. There are other forms of assets, however, that constantly tend to depreciate in value, and this depreciation may be very rapid. For example, buildings waste away by reason of the action of the elements, as well as by the normal wear and tear that they undergo. Machinery, tools and furniture also wear out and must be replaced. Materials and supplies, worked and unworked, may depreciate to scrap value, either from the action of the elements or as a result of becoming obsolete thru changes in the art.

Such losses must be compensated for if the business is to continue and make profits. The subject of depreciation has, therefore, steadily assumed greater

[1] See also discussion of "Depreciation" in the Modern Business Text on "Accounting Principles."

and greater importance. Altho in the past purely a matter of private interest, it has now become a decided factor in the regulation of public utility corporations, and in other legal procedure. Anything approaching a comprehensive discussion of this subject is far beyond our present scope; therefore, only enough will be included to indicate its place in cost-finding practice.

2. *Capital account and revenue account.*—A careful distinction should be made between losses on capital account and losses on revenue account. If an uninsured building is burned, or if an uninsured vessel is lost at sea, the loss so sustained is a loss of capital which is in no way connected with depreciation. No allowance which the owner can make for wasting depreciation of other assets can properly be used to replace the building or the vessel. Such replacement should come out of new capital, whether it be taken from savings or borrowed elsewhere.

Suppose, however, that a company begins business with \$500,000 and, at the end of a given period of time, finds that after having made allowance for wasting losses, and having suffered no losses on capital account, its assets are worth only \$400,000. The company is said, then, to have suffered a loss of \$100,000 on revenue or trading account. Depreciation is one of the factors that enter into, and greatly affect, loss or gain on revenue account. For, if the natural wasting losses on buildings and machinery are not provided for in the costs, and, as a conse-

quence the balance sheet shows a deficit when such losses are provided for, the enterprise has suffered a loss in revenue account because of this procedure. Wasting losses of this kind are a just charge against production and, as will be seen, should be included in manufacturing expenses.

3. *Forms of depreciation, wear and tear.*—The detail in which cognizance is taken of depreciation will vary widely with the enterprise. Thus, in the appraisal of public utilities where toll rates are to be fixed upon the basis of valuation, the following forms of lessening value are often recognized:

(a Wear and tear, or maintenance
(b) Physical decay or decrepitude
(c) Deferred maintenance, or neglect
(d) Inadequacy
(e) Obsolescence.

In simpler cases less detail is necessary and these items are then grouped under two or three heads.

Under wear and tear is included the ordinary wasting away as a result of use and the action of the elements. All machines tend to wear out, the paint on buildings wears away, fences constantly break down, etc. All such wasting losses that can be compensated for by ordinary running repairs and renewals are classed under wear and tear. Under this head also may be included the results of accidents or sudden damage from unpreventable causes. The rate at which such wasting progresses will manifestly vary quite widely with the asset and the service. In

some classes of assets the fall in value may be very rapid in the beginning of service, slowing up as time goes on; while in other cases the reverse may occur, the rate of depreciation becoming greater as the asset nears the end of its usefulness.

4. *Physical decay, neglect.*—Many assets, such as buildings and machinery, even tho kept in the best of repair, will in time reach a state where repairs will no longer suffice and the entire asset must be renewed. A horse is a striking example of this form of asset. His shoes may be replaced, but no repairs or renewals can stay the gradual breaking down of his physical powers. In time he must be replaced. Depreciation of this kind is called physical decay, or decrepitude. It should be noted that depreciation because of age takes place whether the asset is in use or not. Thus buildings, boilers, insulation, etc., may waste away more rapidly when standing idle than when they are in use, and it is common experience that all properties, even when kept in good repair, eventually reach a physical state where repairs and detail renewals are no longer sufficient, and the asset must be replaced entirely.

In refined methods of appraisal, account is taken of the value of an asset, as it really exists, and the value it would have if properly repaired. Even when a plant is kept in the best of repair, it has been shown that its value must steadily decrease. If, however, repairs and renewals are neglected, the value of the asset will necessarily fall below what it would be if

kept in repair, and the amount it falls is called deferred maintenance, or neglect. Since deferred maintenance represents the amount that must be expended to restore the asset to normal condition, it is also a measure of the efficiency with which the plant has been managed, so far, at least, as its physical care is concerned.

5. *Inadequacy and obsolescence.*—Sometimes an asset must be replaced even tho it is in the best of repair, because it is no longer adequate for the work at hand. Thus, a steam crane may become too small for a growing industry, tho it may still be in good condition; or an engine may prove to be unable to drive a factory that has outgrown it, tho it may be as efficient as when it was installed. Such decreased value is known as inadequacy, or supersession, and, obviously, has no connection with wear and tear in the ordinary sense, nor is it connected with decrepitude, or decay thru old age.

An asset may become of less value because of the introduction of new methods or machines. This may occur when the asset in question is as good as new, so far as its power of production is concerned; yet the manufacturer cannot afford to be without the improved apparatus. This phase of the problem of depreciation is particularly noticeable in industries that are developing rapidly. During the early days of the growth of the electrical industry changes of this kind were many and rapid. The same difficulty was experienced in New England during the devel-

opment of the textile industry. Such lessening of value is called obsolescence; it is one of the wasting losses which is often most difficult to foresee and make provision for. Special machinery is particularly liable to become obsolescent. A factory manager should exercise careful judgment in purchasing, therefore, in order that he may not be left, at some future time, with a useless machine on his hands.

In appraising public utilities or in settling the differences of opinion between partners or stockholders and bondholders all of the above classes of wasting losses may be, and are, taken into account. It is not difficult to see, also, that sharp differences of opinion may arise between owners as to the exact disposition of these losses. But for the ordinary enterprise, where the owner is desirous of knowing only the total of such loses, it is usual to group them all under two heads, namely, depreciation and obsolescence—depreciation including wear and tear, decrepitude and neglect, and obsolescence including inadequacy also.

6. *Relation between depreciation and repairs.*—It will be clear that repairs and renewals tend to compensate for wasting losses, but from the foregoing it is also clear that in most cases complete compensation for depreciation, by means of repairs, is not possible. In large plants, consisting of many units that wear out so quickly as to need frequent and complete renewals, such compensation is sometimes possible. For example, in pottery works, where the kilns must

be frequently rebuilt, it is conceivable that if there are enough kilns the renewals may practically balance depreciation. In the case of large railways, where renewals and additions are constantly being made, it is often considered that depreciation is thus compensated for. But it is evident that in such cases there should be an obvious increase in the productive capacity of the plant to insure against gradual lessening of the assets. Even when a machine or building is kept in good repair there is necessarily, as already noted, a lessening of its productive power that cannot be stayed by repairs and renewals.

On the other hand, extensive repairs and renewals may be made on an asset, which may be considered as increasing its earning value and hence increasing its inventory value. Thus a machine may have a certain depreciated value, when extensive repairs and renewals amounting to a large sum may be expended upon it. If the producing power of the tool is increased it would be allowable to increase the value of the machine and make such an entry on the plant ledger. But as already noted, it should be very clear that the earning capacity has been augmented before the inventory value is raised; otherwise, the cost of the repairs should be charged to manufacturing expense.

7. *Relation between depreciation and capital.*—It appears from the foregoing discussion that if the capital invested is to be maintained, the wasting losses due to depreciation must be carefully and sys-

tematically compensated for. Now there is only one source from which these losses can be compensated for, namely, revenue from output. It is a fundamental principle, therefore, that no profits should be considered until all losses to capital thru depreciation have been replaced from earnings.

This principle is very clear when applied to such enterprises as are limited in time, as, for instance, a mine. In such a case the investment is represented by the cost of the land acquired, the cost of sinking the shaft and running the tunnels, the cost of the machinery and equipment, with such cash, etc., as may be necessary to carry on the operations. When the ore is extracted the land may be valueless, and the machinery, even tho in good repair, may be equally valueless, because of its special character and the place where it is located. Obviously, the operator should sell his ore at a rate that will return to him his original investment, plus the cost of operation and plus such a profit as he can obtain on the venture. Clearly, he cannot say that he has made a profit until he has recovered his original investment and paid for all operating expenses.

One important feature of depreciation in its relation to capital is its elusive character. The general books of any concern usually give minute details regarding the changes in cash, accounts receivable and material in process, but the wasting changes that take place in buildings and equipment are seldom accurately known. Furthermore, as will be shown,

they are particularly difficult to evaluate, since, unlike changes in cash and other current assets, they do not force themselves upon the attention of the accountant.

The very elusiveness of depreciation often gives rise to wide differences of opinion in cases where the enterprise is owned by several parties, and especially when both bondholders and stockholders are interested. The bondholder who is assured of a return on his investment very naturally will insist that the plant be kept in good repair, since that is necessary to insure the permanency of his capital. The stockholder, free to sell his stock at any time, is more interested in dividends, and may not object if profits are paid out of capital because of insufficient attention to depreciation. The problem, therefore, of dealing fairly with the bondholders who are the creditors and with the stockholders who should have a fair return on the stock, is intimately connected with depreciation.

8. *Original, present and scrap values.*—It may be noted in passing that the value of any asset will vary with the purpose for which the valuation is made. There is a great difference between the value of a plant viewed as a "going concern," and its value at forced sale. In appraising public utilities, for instance, several kinds of value are recognized. Thus the "service value," or the value as measured by the effectiveness of the asset at that particular time, may be considered important, since this value may be

high, tho the asset itself may be old or depreciated. Again, the value of "cost of reproduction," or the value as measured by the cost of replacing the asset with new apparatus of equal effectiveness, is often an important consideration in the appraisal of public utilities. In the usual factory inventory, however, the "original cost," "residual" or "scrap" value and the "present value," are the most important values with which the factory manager and the cost keeper are concerned.

The original cost is the cost of the asset plus freight and cartage, excluding foundation and erection costs, since these are irrecoverable and should be included in preliminary expense and written off independently. Some acountants include erection costs in the original value, on the ground that they are not expenses properly chargeable to the current period, and that depreciation charges will eventually dispose of them. This view, it would seem, loses sight of the fact that the assets are thereby unduly inflated.

While it is true that such charges are, strictly speaking, a part of the investment, they are of such an evanescent character that they should be recovered as soon as possible. A machine does not change in value if moved to a new location, but the value of the outlay, incident to its erection on the original site, vanishes the instant that it is moved; while the foundation, instead of being of value is, in many cases, such as to render removal or remodeling dif-

ficult and expensive. Depreciation has to do with a different kind of lessening value, and it is much better to carry erection and foundation expenses to a suspense-development account and write them off as quickly as possible.

The "residual" or "scrap" value of an asset is its estimated market value at the end of the probable producing life.

The "present value" of an asset is the value found by subtracting the total depreciation, to date, from the original cost, due allowance being made for any renewals that have been carried to the plant-ledger account of the asset.

The foregoing discussion deals with assets that are "tangible" or "visible" but, in addition to such assets, there are often others that are "intangible" or "invisible." In this class would be included the cost of preliminary surveys, legal expenses of organization, cost of franchises and patents, and other short-lived assets. Many of these may constitute a true part of the cost of the plant or may be indispensable to its operation, but while extremely valuable to the enterprise as a "going concern," their actual market value may be very small. Best practice, therefore, carries all such assets to "development accounts," making provision for depreciating such accounts out of existence by means of a reserve. Such methods will be described in a later section.

9. *Determination of depreciation.*—All intelligent managers admit the necessity of making allowance

for depreciation, but there is much diversity of opinion regarding the methods to be pursued in doing so. One of the reasons for this diversity of opinion is that enterprises vary widely, and, in addition, it is not always expedient to make as large a deduction for depreciation as may seem desirable. An old, and still common, method is to make an annual visual inventory of every asset, the total value so obtained being the apparent inventory value of the plant. By comparison with the inventory of former years the depreciation is determined and deducted from gross profit before dividends are declared. While such a method seems practical and satisfactory for enterprises which close their books annually only, it has several disadvantages, and there are objections to its use. A visual examination may or may not be sufficient for a correct valuation of the assets, and such methods of valuation require judgment backed by long practical experience. A periodical visual examination is, however, a good check on the methods to be described, for such a visual inventory often brings to light material and apparatus that have depreciated greatly tho appearing on the plant ledger or the stores or finished-product ledger at full cost.

More advanced practice, however, provides[1] for a continuous inventory of all physical assets, and makes further provisions for definite and systematic depreciation, as indicated on the plant-ledger card shown in Figure 13 (page 122). The depreciation so

[1] See Modern Business Text on "Plant Management."

determined is distributed in the factory expense and becomes an integral part of the cost of production.

10. *General method of depreciation.*—In laying out a systematic plan for depreciating any asset it will be necesary, therefore, to know the original cost of the asset, the estimated productive life of the asset, and the probable "scrap value" of the building or machine at the end of this productive life. Some definite rate of depreciation is then decided upon that will reduce the original value to the "scrap value" at the end of the life period. It should be remembered that repairs, or renewals, or obsolescence, may make necessary some modification of the plan laid down, and it may be necessary, as circumstances change, to change the rate of depreciation.

The general method of depreciating an asset may be illustrated as follows: Suppose an asset has an original value of $5,000 and when installed its estimated producing life is set at twenty years, at the end of which period it is estimated that its "scrap value" will be $500. The total depreciation which must be cared for, not considering modifying repairs or renewals, will be, therefore $5,000 — $500 = $4,500. Suppose, now, that at the end of ten years the book value of the asset has been reduced by the method of depreciation in use to $2,000, and at that time the asset receives repairs and renewals amounting to $1,000. If such renewals bring the asset up to somewhere near the producing value of a new piece of apparatus of similar kind, it appears logical to

increase the book value to, say, $2,500 and readjust the rate of depreciation, if desirable. On the other hand, at the end of the fifth year, the asset may be found to be in first-class repair, but almost valueless as a producing asset, because of new inventions, or changes in processes. Thus, it is clear that the "scrap value" and the producing life depend on many factors and must, as a rule, be estimated.

There are several methods advocated, and in use, for fixing the rate at which the asset shall be depreciated from the original cost to "scrap value." This is necessarily so, since conditions vary and personal opinions govern these matters to a large degree. The three most important of these methods to be discussed at this point are percentage on original cost, percentage on diminishing value, and sinking fund.

11. *Percentage on original cost.*—Under the plan known as percentage on original cost, the total depreciation, or the difference between the original cost and the "scrap value," is divided by the estimated producing life, and the quotient is the amount set aside annually for depreciation. Thus, in the preceding example the annual depreciation would be $225. Since the same amount is deducted annually from the value of the asset the decline in value is uniform and, hence, follows a straight line. For this reason this method is sometimes designated "straight line" depreciation.

This method of depreciation has been much used because of its simplicity and because it does not make

such a heavy reduction in inventory values in the beginning of the life of the asset as does the method of percentage on diminishing value. This is an undoubted advantage for a new enterprise that has a scanty income during the early years of its existence. On the other hand, it is undoubtedly true that, with many assets, the depreciation is much greater during the early years of use than during the later years.

12. *Percentage on diminishing value.*—It is also argued against the straight-line depreciation method that it is more desirable to depreciate heavily during the early years, when repairs and renewals are not costly, and to depreciate less heavily during the later years, when repairs begin to become more burdensome. For this reason, and others, some managers prefer the method of percentage on diminishing value. Under this system a definite percentage is taken each year from the depreciated value of the preceding year. Thus, in the case already mentioned, if the rate of depreciation be taken at 10 per cent, and this percentage be taken annually from the depreciated value of the year before, the same results will be obtained as with the other method. It will be clear that under this last method the depreciation will be much heavier during the early years and much lighter during the later years, for the same producing life and "residual" value than under the straight-line method. The computation of depreciation by percentage on diminishing value will be facilitated by the use of Table 1, which follows.

TABLE 1 DEPRECIATED VALUE OF UNITY AT DIFFERENT RATES FOR TERMS OF YEARS.

YEARS	1%	1¼%	1½%	2%	2½%	3%	4%	YEARS
0	1.000,000	1.000,000	1.000,000	1.000,000	1.000,000	1.000,000	1.000,000	0
1	0.990,000	0.987,500	0.985,000	0.980,000	0.975,000	0.970,000	0.960,000	1
2	0.980,100	0.975,156	0.970,225	0.960,400	0.950,625	0.940,000	0.921,600	2
3	0.970,299	0.962,967	0.955,671	0.941,192	0.926,859	0.912,673	0.884,736	3
4	0.960,596	0.950,930	0.941,336	0.922,368	0.903,688	0.885,292	0.849,346	4
5	0.950,990	0.939,043	0.927,216	0.903,921	0.881,099	0.858,734	0.815,372	5
6	0.941,480	0.927,305	0.913,308	0.885,843	0.859,068	0.832,972	0.782,757	6
7	0.932,066	0.915,714	0.899,608	0.868,126	0.837,591	0.807,982	0.751,477	7
8	0.922,745	0.904,267	0.886,114	0.850,763	0.816,652	0.783,743	0.721,389	8
9	0.913,517	0.892,964	0.872,822	0.833,748	0.796,235	0.760,231	0.692,534	9
10	0.904,382	0.881,802	0.859,730	0.817,073	0.776,329	0.737,424	0.664,832	10
11	0.895,338	0.870,779	0.846,834	0.800,732	0.756,921	0.715,301	0.638,239	11
12	0.886,385	0.859,895	0.834,131	0.784,717	0.737,998	0.693,842	0.612,709	12
13	0.877,522	0.849,146	0.821,619	0.769,023	0.719,548	0.673,026	0.588,201	13
14	0.868,746	0.838,532	0.809,295	0.753,643	0.701,559	0.652,836	0.564,673	14
15	0.860,059	0.828,050	0.797,155	0.738,570	0.684,020	0.633,250	0.542,086	15
16	0.851,485	0.817,699	0.785,198	0.723,798	0.666,920	0.614,253	0.520,402	16
17	0.842,943	0.807,478	0.773,420	0.709,323	0.650,247	0.595,825	0.499,586	17
18	0.834,514	0.797,385	0.761,819	0.695,136	0.633,991	0.577,950	0.479,603	18
19	0.826,169	0.787,417	0.750,391	0.681,233	0.618,141	0.560,612	0.460,419	19
20	0.817,907	0.777,574	0.739,135	0.667,609	0.602,572	0.543,794	0.440,002	20
21	0.809,728	0.767,855	0.728,048	0.654,245	0.587,620	0.527,300	0.424,332	21
22	0.801,631	0.758,257	0.717,128	0.641,171	0.572,930	0.511,655	0.407,349	22
23	0.793,615	0.748,778	0.706,371	0.628,348	0.558,606	0.496,306	0.391,055	23
24	0.785,678	0.739,419	0.695,775	0.615,781	0.544,641	0.481,416	0.375,413	24
25	0.777,822	0.730,176	0.685,338	0.603,466	0.531,025	0.466,974	0.360,396	25
26	0.770,043	0.721,049	0.675,058	0.591,396	0.517,749	0.452,965	0.345,980	26
27	0.762,343	0.712,036	0.664,932	0.579,568	0.504,806	0.439,376	0.332,141	27
28	0.754,720	0.703,135	0.654,958	0.567,977	0.492,185	0.426,194	0.318,855	28
29	0.747,172	0.694,346	0.645,134	0.556,618	0.479,881	0.413,408	0.306,101	29
30	0.739,701	0.685,667	0.635,457	0.545,485	0.467,884	0.401,006	0.293,857	30
40	0.688,972	0.604,622	0.546,321	0.445,701	0.363,232	0.295,711	0.195,366	40
50	0.605,066	0.533,157	0.469,689	0.364,171	0.281,988	0.218,065	0.129,885	50

TABLE 1 CONTINUED.

YEARS	5%	6%	7½%	10%	12½%	15%	20%	YEARS
0	1.000,000	1.000,000	1.000,000	1.000,000	1.000.000	1.000,000	1.000,000	0
1	0.950,000	0.940,000	0.925,000	0.900,000	0.875,000	0.850,000	0.800,000	1
2	0.902,500	0.883,600	0.855,625	0.810,000	0.765,625	0.722,500	0.640,000	2
3	0.857,375	0.830,584	0.791,453	0.729,000	0.669,922	0.614,125	0.512,000	3
4	0.814,506	0.780,749	0.732,094	0.656,100	0.586,182	0.522,006	0.409,600	4
5	0.773,781	0.733,904	0.677,187	0.590,490	0.512,909	0.443,705	0.327,680	5
6	0.735,092	0.689,870	0.626,398	0.531,441	0.448,796	0.377,149	0.262,144	6
7	0.698,337	0.648,478	0.579,418	0.478,297	0.392,696	0.320,577	0.209,715	7
8	0.663,420	0.609,569	0.535,962	0.430,467	0.343,609	0.272,490	0.167,772	8
9	0.630,249	0.572,995	0.495,761	0.387,420	0.300,658	0.231,617	0.134,218	9
10	0.598,737	0.538,616	0.458,582	0.348,678	0.263,076	0.196,874	0.107,372	10
11	0.568,800	0.506,299	0.424,188	0.313,811	0.230,191	0.167,343	0.085,899	11
12	0.540,360	0.475,921	0.392,374	0.282,429	0.201,418	0.142,232	0.068,720	12
13	0.513,342	0.447,366	0.362,946	0.254,186	0.176,240	0.120,905	0.054,976	13
14	0.487,675	0.420,524	0.335,725	0.228,768	0.154,210	0.102,770	0.043,981	14
15	0.463,291	0.395,292	0.310,546	0.205,891	0.134,934	0.087,354	0.035,184	15
16	0.440,127	0.371,575	0.287,255	0.185,302	0.118,067	0.074,251	0.028,148	16
17	0.418,200	0.349,281	0.265,711	0.166,772	0.103,309	0.063,113	0.022,518	17
18	0.397,214	0.328,321	0.245,782	0.150,095	0.090,395	0.053,646	0.018,014	18
19	0.377,354	0.308,621	0.227,349	0.135,085	0.079,096	0.045,599	0.014,412	19
20	0.358,486	0.290,107	0.210,297	0.121,577	0.069,209	0.038,760	0.011,529	20
21	0.340,562	0.272,701	0.194,525	0.109,419	0.060,558	0.032,946	0.009,223	21
22	0.323,533	0.256,358	0.179,936	0.098,477	0.052,988	0.028,004	0.007,379	22
23	0.307,357	0.240,958	0.166,441	0.088,629	0.046,365	0.023,803	0.005,903	23
24	0.291,989	0.226,501	0.153,957	0.079,766	0.040,569	0.020,233	0.004,722	24
25	0.277,390	0.212,911	0.142,111	0.071,790	0.035,498	0.017,198	0.003,778	25
26	0.263,520	0.200,136	0.131,730	0.064,611	0.031,061	0.014,618	0.003,022	26
27	0.250,344	0.188,128	0.121,850	0.058,150	0.027,178	0.012,425	0.002,418	27
28	0.237,827	0.176,840	0.112,711	0.052,335	0.023,781	0.010,562	0.001,934	28
29	0.225,935	0.166,230	0.104,258	0.047,101	0.020,808	0.008,977	0.001,547	29
30	0.214,639	0.156,256	0.096,439	0.042,391	0.018,207	0.007,631	0.001,238	30
40	0.128,512	0.084,162	0.044,225	0.014,781	0.004,790	0.001,502	0.001,133	40
50	0.076,945	0.045,331	0.020,281	0.005,154	0.001,260	0.000,296	0.000,014	50

13. *Sinking fund.*—Some accountants use the sinking-fund method in caring for depreciation. Under this scheme such an annual sum is set aside as, at compound interest, will amount by the end of the producing life to the original cost of the asset, minus the "scrap value." There are several objections to this method. First, it is unnecessarily cumbersome, mathematically; and second, as it is usually applied to ordinary depreciation, it is faulty in theory. Depreciation is an allowance for losses that have already occurred. If this loss is $200, yearly, that amount should be set aside, and not the amount which will accumulate to that value in a period of years. It will be noted, furthermore, that this method usually withdraws capital from the enterprise, and it does not seem to be a good financial policy to set aside earnings to draw interest at bank rates when, by retaining them in the business, a higher rate of interest could, presumably, be obtained. If the enterprise cannot produce earnings higher than bank interest it might as well go out of business and place all of its capital in the banks, thus avoiding, to a considerable extent, the risks incident to a business venture.

14. *Typical rates of depreciation.*—The rates of depreciation will, as before noted, vary widely with the asset and the service. A single flat rate applied to all assets is unintelligent and misleading. Careful classification should, therefore, be made of all assets, and proper rates should be assigned; at the same

time the controlling factors—original cost, estimated life and "scrap value"—should be constantly borne in mind. The rate that should be assigned to any class of asset will depend largely upon circumstances, and nothing more than suggestions can be

TABLE 2

ESTIMATED LIFE AND FACTORS OF DEPRECIATION

Asset	Probable life of asset in years	Ratio of scrap to original value	Percentage on original cost	Percentage on diminishing value
Brick or steel frame buildings, easy service	40	0.10	2.25	5.5
Brick or steel frame buildings, severe service	20	0.10	4.5	11.
Good wooden buildings, easy service	30	0.10	3.	7.5
Good wooden buildings, severe service	15	0.10	6.	14.
Steam-engines	15 to 30	0.10	6 to 3	14 to 7.5
Steam-boilers	15 to 30	0.10	6 to 3	14 to 7.5
Boiler-room feed pumps	20	0.05	4.75	14.
Engine-room instruments and gauges	10	0.05	9.5	26.
Steam piping, valves and fittings	10 to 15	0.05	9.5 to 6.3	26 to 18
Portable engines and boilers	10	0.05	9.5	26.
Gas engines	10 to 15	0.05	9.5 to 6.3	26 to 18
Turbo-generators	20 to 30	0.10	4.5 to 3	11 to 7.5
Electric generators	20 to 30	0.10	4.5 to 3	11 to 7.5
Electric motors	20	0.10	4.5	11.
Storage batteries	10	0.05	9.5	26.
Switchboards and instruments	15	0.05	6.3	18.
Heavy machine tools	25	0.10	3.6	9.
Light machine tools	15 to 20	0.10	6 to 4.5	14 to 11
Shafting, hangers and pulleys	20 to 30	0.05	4.75 to 3	14 to 9
Belting	10 to 25	...	10 to 4	....

offered here. Judgment and expediency are always important factors in the fixing of these rates. The above table, taken from the author's "Principles of Industrial Organization," gives average rates for

buildings and machinery kept in a good state of repair. These rates also include allowance for obsolescence. Corresponding rates are given for the methods of depreciation which have been discussed.

15. *Depreciation, a manufacturing expense.*—It should be specially noted that depreciation is a manufacturing expense and not a general expense, as it is so often considered. There is no logical justification for distributing depreciation as an even layer over the total shop costs, since the rate of depreciation varies so greatly with various assets. At the least, it should be allocated by departments in common with all manufacturing expenses, and all the arguments presented later on, looking to a still more accurate distribution of all costs, are applicable, also, to depreciation.

The amounts set aside for depreciation should, then, be distributed against production, credited in some manner to the equipment accounts and debited to the depreciation accounts. The exact method of handling a depreciation reserve is a problem for the accountant and the financier. Sometimes, an offsetting fund is created and put at interest outside the business; on the other hand, it is more often retained as working capital.

In conclusion, it should be remembered that mathematical methods of depreciation cannot always be rigidly adhered to. Conditions change from year to year, and the state of trade may make it desirable to modify what may have previously been an excellent

practice. The all-important fact to remember is, that depreciation is a very definite expense which must be met, and any well-defined method of determining this depreciation, even tho it cannot be absolutely adhered to, is a safeguard against a day of reckoning that might prove fatal to the enterprise.

REVIEW

How would you distinguish the following forms of lessening value:

(a) Wear and tear, or maintenance?
(b) Physical decay, or decrepitude?
(c) Deferred maintenance, or neglect?
(d) Inadequacy?
(e) Obsolescence?

Why is depreciation in the nature of an expense item and not a part of the disposition of the profits?

What are the advantages and disadvantages of the different methods of providing for depreciation? How does your comparison of these coincide with that in the text?

In your opinion would a company be wise in omitting depreciation charges in any year because this element of loss was fully covered by an appreciation in the value of fixed assets?

What is a fair estimate of the probable life of the following assets: Steel frame buildings, easy service; good wooden buildings, severe service; steam engines; heavy machine tools; belting?

How would you calculate the annual charge for depreciation of an asset by each of the methods indicated in the text? How do your conclusions check with those of the text?

CHAPTER X

DISTRIBUTION OF FACTORY EXPENSE

1. *General.*—From the foregoing discussion it will be clear that while the cost of direct labor and direct material can, in general, be allocated with a fair degree of accuracy to the jobs into which they enter, the problem of distributing the factory expense so that each job shall bear its share of burden is difficult and is one that seldom admits of an accurate solution. Expense items differ in their characteristics, and industrial enterprises themselves vary so widely both in size and character that it is not possible to formulate any one system of distributing expense that will be universally applicable and that will give accurate results. It should be remembered. also, that the difficulty of allocating expense grows with the size of the industry and becomes more complex as the number of lines of goods increase.

Nevertheless, it is essential that these expenses be allocated as closely as possible, especially where several lines of product are manufactured. Not only should each production order be charged with expense in proportion to the use it has made of the manufacturing facilities, but if close watch is to be kept of these expenses their distribution should show the departmental responsibility for their creation.

On the other hand, managers are usually opposed to complex systems and methods and are content with only a fair degree of accuracy. Nearly all cost-finding systems in use, therefore, are compromises which give approximate costs only. A number of these approximate methods are in wide use and it may be helpful to discuss briefly the characteristics and limitations of the most important ones. It will be understood also that the present discussion refers to the distribution of factory or manufacturing expense, the distribution of general expense being treated separately later on.

The basic principle of all of these methods is to use some tangible element in the job as a basis of comparison by which to measure the indirect expense which should be charged against it. It will be remembered that direct material and direct labor are tangible elements that attach themselves to all jobs in a direct and measurable fashion. The time expended upon a job is also an element that can be determined accurately, whether it be the time of the workman himself or the time of a machine which has been used. Practically all systems of expense distribution assume that one or more of these tangible elements will form a measure of the proportionate amount of expense that the job should bear. The most important of these systems, which will be briefly discussed, are:

(a) Distribution by percentage on material cost

(b) Distribution by percentage on labor cost
(c) Distribution by percentage on prime cost
(d) Distribution by percentage on man-hours
(e) Distribution by machine rates

For simplicity, it will be assumed at present that these systems are applicable to the distribution of the factory expense as a whole disregarding any limitations to this supposition which will be discussed at a later point. A more advanced and more accurate method known as distribution by production factors deserves special attention and will receive consideration later.

2. *Distribution by percentage on material cost.*—In distributing expense by percentage on the material cost it is assumed that the burden varies directly with the amount or cost of the material that enters into the product. Suppose, for instance, that a machine is built involving an outlay of $300 for direct labor, and $100 for direct material. Suppose, further, that during the period of its construction the total expenditure in the factory for material is $2,-500 and the total expense for the same period is $5,000. Then by this method of distributing expense the ratio of expense to material for the entire factory would be $\frac{5,000}{2,500} = 2$. The expense which the job in question must bear is then $\$100 \times 2 = \$200$, and the factory cost will be:

Direct labor =	$300
Direct material =	100
Expense =	200
	$600

3. *Advantages and defects.*—It will be clear that in a simple continuous process involving the production of only one commodity, as is the case in a rail mill or a cement plant, where every part of the product makes the same use of all the facilities of the plant, the system discussed in the previous section will often be adequate. It is sufficient, in fact, in such simple cases to divide the entire cost of production by the total weight or volume of the product and establish unit factory costs that are fairly accurate. This is not because of any inherent accuracy in the method, but because, in these simple cases, allocation in a distributive sense is not necessary. All that is required is division of the expense over a uniform product. In other cases, also, where the material value entering the factory product is very large compared with the direct and the indirect labor cost, this method may be sufficiently accurate. The method is applicable also to mercantile establishments where the units handled do not vary widely in size and value, and the cost of storage, insurance, clerical assistance, etc., is fairly constant.

If, however, more than one commodity, or more than one variety of the same commodity, is manufactured, this method of unit cost is clearly inaccu-

rate, unless each unit of each line of product makes equal use of all factory facilities. Furthermore, if the cost of the material is used as a basis, it is very clear that a line of goods involving expensive material will be burdened more than one in which a less valuable material is used. Thus, two pieces of jewelry may be manufactured, alike in every respect, and employing the facilities of the factory to exactly the same extent, one of them being made of gold, and one of some less valuable material—clearly, the product made of the more valuable material will be compelled, under this method, to carry more than its just share of expense.

It would be logical, again, to charge more of the foundry expense against a large casting than against a small one; but in the machine shop the large casting might have a very small amount of work done upon it, while the small one might require many hours of labor and machine work. In this case, therefore, the small casting might be entitled to a much heavier machine-shop expense than the larger one. Manufacturers using this method of distributing expense will experience difficulty in competing, in jobs involving much material and little work, against rival manufacturers using other and more logical methods.

Despite these obvious defects, however, the method is often useful and sufficiently accurate in handling such departments as foundries and porcelain works attached to factories of the intermittent types,

especially if the product of these departments is fairly uniform in character and size, and is passed thru in large lots for stock orders. The limitations of this system are most apparent where the product is varied in quantity and size.

4. *Distribution by percentage on labor cost.*—In distributing the expense by percentage on labor cost it is assumed that the burden varies directly with the direct labor expended upon the job. Thus, with the data assumed in Section 2 of this chapter, suppose that the total direct labor for the given period is \$4,000. Then, in the preceding example the ratio of expense to direct labor would be $\frac{\$5,000}{\$4,000} = 1.25$. The expense which the job in question must bear is therefore $\$300 \times 1.25 = \$375$, and the total factory cost will be:

Direct labor =	\$300
Direct material =	100
Expense =	375
	\$775

This result, as might be expected, differs materially from the cost obtained with material as the basis, since there is no connection between the relative amounts of material and labor that enter into the product. The amounts assumed above for these items, while taken at random, are entirely probable and illustrate the principle involved.

5. *Advantages and defects.*—In shops where the

products are closely similar in kind and do not differ greatly in size this method may, in many cases, give results accurate enough to justify its use. In justification of the method it is sometimes urged that the indirect labor varies quite closely with the direct labor, and that, therefore, the direct labor is a measure of expense. Granting that this may be true, tho it is not always so, it should be remembered that expense is composed of several other items besides indirect labor, and that these items neither are connected in any way with direct labor, nor vary directly with it. Because of its simplicity and because wages are such an important and evident part of the cost of production, this method has been, and still is, in extensive use. It has, however, serious limitations.

First, this method does not discriminate between the cost of work done by a rapid workman and the cost of work done by one less rapid. Thus, a job which takes a rapid man, receiving sixty cents per hour, four hours to complete, is burdened with the same expense as a job done by a slower man, earning forty cents, and requiring six hours of his time. This method of distributing the expense, therefore, does not differentiate between these two men in the final shop costs. Yet the slower man has employed to a greater degree the shop facilities—power, heat, lighting, floor space, tools, etc.— and, very clearly, has caused the work to cost the firm much more than it did in the case of the more rapid workman. Then,

too, because of the decreased rate of output due to the slower man, there is less total product over which to spread the expense, and each part must bear a greater proportion as the rate of production falls, since, as already explained, expense does not vary directly with product, but increases relatively as production decreases.

This method also fails entirely to differentiate between the cost of large work and the cost of small work, and the error involved in its use may become large where the size of product and the size of the machinery required, vary widely. Thus, the expense charged to a job involving labor worth $10 by a mechanic using a file only, is exactly the same under this method as that laid upon a job involving the same labor charge, but done by a very large boring mill requiring the use of much greater floor space, heating, lighting and power, as well, perhaps, as the service of a large overhead crane. The work done on a very costly automatic machine will under this method, bear practically no expense burden, tho it is evident that the interest charge, alone, is much greater for the automatic machine than for hand work, which may bear heavy expense charges. In brief, this method of distributing expense is a crude method of averaging, and fails wherever the indirect expenses vary, since it does not give accurate results in proportion to the variation in the components of the expense to be distributed.

It will be evident, however, that in shops where the parts manufactured are of approximately the same size and character this method may be fairly applicable. The same will be true of very large plants where the volume of work is so large as to permit of careful classification and departmentization so that the work in all the departments is similar in size and character. In such cases a different percentage may be necessary for each class or department and, obviously, this departmental method will give more accurate results in plants doing mixed work than can be obtained by a flat rate on the entire product. It may be noted in passing that departmentization may not always give the desired result. If one department, for instance, is devoted entirely to generators, another to motors, and another to transformers, great differences may still exist in the size and character of parts within each department. If, however, the departmentization groups all lathes of one approximate size together, all the large boring machines together, and so on, this method is clearly more applicable. This matter will receive further attention in a later section.

6. *Distribution by percentage on prime cost.*—In the distribution of expense by percentage on prime cost it is assumed that the expense varies directly with the prime cost. Thus, using the same data as in the preceding examples, the ratio of expense to prime cost will be:

$\frac{\$5{,}000}{\$4{,}000 + \$2{,}500} = .77$. The expense, therefore, for the job under consideration will be $(\$100 + \$300) \times .77 = \$308$, and the factory cost will be:

Direct labor =	$300
Direct material =	100
Expense =	308
	$708

7. *Advantages and defects.*—Distribution by percentage on prime cost has the same inherent defects and limitations as the methods previously discussed, since it combines the bases of both of them. Where the value of the direct labor entering into the product is small compared with the value of the material, the method approaches the plan of distribution by percentage on material. On the other hand, if the material value is relatively low, the method approaches the plan of distribution by percentage on labor. In either case there are involved the errors and limitations contained in one or the other of those plans.

In the general case of a factory making a product, varied both as to character and size, one piece may have a relatively high labor value and the very next one may have a relatively low labor value; distribution by this method is, in such a case, not only inaccurate, but illogical. A manufacturer doing a mixed business will find difficulty in competing on jobs in-

volving much material and little labor if his costs are based on this method. Even tho other work which he performs may justly receive a large amount of expense, the selling of a product consisting of little but material does not, in general, involve much factory expense. In fact, in the extreme case, such goods may not even enter the factory, but may pass directly from the source of supplies to the customer.

8. *Distribution by percentage on man-hours.*—In distributing the total expense by percentage on man-hours it is assumed that the expense which any piece of work should bear is directly proportional to the number of man-hours that have been expended upon it. Suppose that, as in the example already used, the total direct labor is $4,000, and is made up of 12,500 man-hours at varying rates. Assume also that the total expense is $5,000 and the total material is $2,500, as in the previous cases. Assume also, as before, that the direct material used on the job under consideration is worth $100 and the direct labor cost is $300; but assume, moreover, that this labor is made up of 1,200 man-hours at twenty-five cents per hour. Then the expense per man-hour chargeable against every job will be $\frac{\$5,000}{12,500} = \$.40$, and the expense which must be allocated to the job under consideration will be $\$.40 \times 1,200 = \$480$, whence the shop cost of the job will be:

$$
\begin{aligned}
\text{Direct labor} &= \$300 \\
\text{Direct material} &= 100 \\
\text{Expense} &= 480 \\
\hline
&\ \$880
\end{aligned}
$$

9. *Advantages and defects.*—It might seem at first glance that the man-hours method would give the same results as distribution by percentage on labor alone, and this would be the case if all men received exactly the same rate of wages. Thus, suppose that the total direct labor of $4,000 consisted of 16,000 hours at twenty-five cents per hour. Then the expense chargeable against each man-hour would be $\frac{\$5,000}{16,000} = \$.3125$, and the expense chargeable against the job under consideration would be $\$.3125 \times 1,200 = \$375$, or the same as in the method of distribution by percentage on labor cost.

On the other hand, if the job under consideration received 1,500 hours at twenty cents per hour, or a total of $300 as before, the expense allocated to it by this method would be of $\$.40 \times 1,500 = \$600$, and the shop cost would be $\$300 + \$100 + \$600 = \$1,000$. Again, if it received 500 hours at sixty cents per hour, making the same total labor cost as before, the expense chargeable to it would be only $\$.40 \times 500 = \$200$, and the shop cost would be only $600. It will be seen, therefore, that under this method the total labor cost may be the same on different jobs, but the

expense may vary widely. This method, then, takes into account the element of time spent, the factory cost decreasing and increasing with this factor. A job done by a high-priced man in a short time, and with minimum use of the shop facilities, is not burdened so heavily as one done by a cheaper and slower man who uses the shop facilities for a much longer period. This is logical, and in this respect the method of percentage on man-hours is an advance on the systems previously discussed.

The method of percentage on man-hours would seem to be more logical, in general, than that known as percentage on labor for other reasons. A great many of the principal items of indirect cost as, for instance, heat, light, depreciation, rent, insurance, taxes, interest, etc., are more fairly proportional to time than to wages or labor costs. There is no reason for assuming that the proportion of these items will be high where wages are high, and low where wages are low; in fact, such items as supervision are likely to be highest where labor costs are lowest. The interest on investment may be very high where low-priced labor is employed in operating automatic and semi-automatic machines.

On the other hand, this method is no better than that of percentage on labor, so far as differentiation between the use of equipment of different value and size is concerned. The same hourly rate is applied to a hand worker as is applied to a $20,000 boring mill. This results in overcharging small, cheap product,

and undercharging the larger and more expensive work. When applied over an entire factory which is engaged in making a wide range of work, competition with the small articles of product becomes difficult if such competition is against other manufacturers specializing in these small articles.

It will be evident that this method can be applied with accuracy only when the work is of fairly uniform size and character, but it should also be noted that the errors of this method, like those of the percentage-on-labor plan, can be obviated to some extent by careful departmentization. Where tools and processes can be grouped so as to obtain equal conditions for similar types of machinery and similar processes, this plan can often be used with success. Like the preceding systems it has the virtue of simplicity and in many cases this is no small advantage.

10. *Inadequacy of foregoing methods.*—It will be clear that under any of the plans of distributing expense that have been discussed an *averaged* result is ultimately obtained. It is clear, also, that the *total* expense can be distributed with certainty by any of these methods. None of them, however, takes account of the fact that expense does not weigh equally upon all parts of the productive activities. It is for this reason that these methods apply with some semblance of accuracy only where the conditions are more or less uniform, where the wages paid do not vary greatly, where the size and character of the equipment do not differ, and where the lines of

product are not diverse in character. In other words, where the conditions are simple, only simple methods are required. It is for this reason, also, that any of the methods that have just been discussed apply more closely when the factory can be departmentized so as to group machines and processes of similar kind and equal size together. Where this can be done, and each department is accurately charged with its share of expense, almost any method of dividing the departmental expense will give fairly satisfactory results, since each man or tool in each department is, generally speaking, equally taxable. Minute departmentization of this character is not usually possible, however, and where these simple conditions do not obtain, and accurate costs are desired, the averaging methods so far described are not applicable with any degree of accuracy.

The reasons which explain this fact are fundamental. When factories were smaller, and machine processes did not constitute so large a factor in manufacturing, either wages or time did, no doubt, serve as a satisfactory measure of expense, especially where only rough costs were required. But neither wages nor labor hours can be taken as a measure of expense in modern factories where the product varies as to both size and character. This is markedly true where machine processes constitute a large portion of the cost of production. The elements of expense that attach themselves to a handworker may be, and generally are, very different in value

from those connected with an expensive automatic machine. The range of processes found in some modern factories is almost bewildering; so much so, in fact, that any distribution of expense by averaging methods may be little short of a wild guess, so far as accurate allocation is concerned. This complexity is still further increased when machines and processes are used intermittently in ever-changing lines of product. It is true, of course, that in all complex cases a certain amount of averaging must be done, but this can be minimized and the results made more accurate than those obtained by the methods heretofore outlined.

11. *Relation between machine processes and expense.*—As a matter of fact, the majority of factory expenses do not attach themselves to labor or to material, but gather around machines and processes. Consider, for instance, the items of interest and depreciation. In the averaging method referred to, these expenses are distributed over the entire product with other items of expense, and lose their identity entirely, so far as any particular machine or process is concerned. Yet these items of expense are intimately connected with individual machines or processes and are definite parts of the cost of operation. They are not connected with the wages of the operator, since they continue to accrue even when the machine is idle. In fact this is one of the fundamental defects in using wages or labor hours as a basis of expense distribution. Many items of expense

continue to accrue even when no wages are being paid and the factory is closed down. It is not logical that an article produced by hand labor should be allowed to bear a portion of the expense equal to that borne by a part machined on a large boring mill; yet this is just what the averaging methods accomplish if they are applied over diverse product of varied size. Similar reasoning applies to such expenses as heat, light, power, insurance, rent, taxes, repairs, and in fact to the greater part of shop expense.

It should be remembered also that the amount of these expenses may be very large. Shop expense frequently amounts to 100 per cent, and sometimes goes as high as 150 per cent, of the direct wages. It is fully as important that this expense be accurately allocated as that the labor cost be correctly recorded. This is particularly true where it is desired to know the cost of different sized articles or different lines of goods, with a view to meeting competition on a correct basis.

12. *Old machine rate.*—When, therefore, the traditional influence of wages and labor hours is once discarded, it becomes clear that many of the items of expense are naturally connected with the use of equipment of one kind or another. Rent, insurance, taxes, interest and depreciation are connected with the use of buildings and machines. Heating, lighting and power are likewise connected as much with machines as with men, and if costs are to be intel-

ligently applied this factor must be taken into account. This aspect of cost finding was recognized in mixed manufacturing many years ago, and so-called machine rates have long been in use. In fact, the conception is a very old one and had its origin, no doubt, in an instinctive effort to discharge the interest on investment and wear and tear of the machine, in a degree in some proportion to its size and cost. This effort probably was a natural result of the growth in the variety and size of machines.

In its original form the machine rate made no effort to insure accurate allocation of the total factory expense, but attempted rather to equalize in some degree such items of expense as clearly attached themselves to machines and processes; it perhaps took into account the probable life of the machine. All machines and processes were divided into a few classes designed often by letters or numbers. A graduated hourly rate was then assigned to each class, and each piece of work done on every machine was taxed accordingly, and in proportion to the time during which it made use of the utility concerned. In most cases, by some averaging method an additional expense charge was added to the factory cost so determined; the profit which was added was sufficient to cover all discrepancies. This method, which might be said to belong to the "stone age" of cost finding, is not to be recommended. It is of importance, however, because of the principle involved.

13. *Modern machine rate.*—As the need for more

accurate costs grew, it was a most natural tendency to extend the method to cover handwork as well as machine processes. Under such systems the hourly burden imposed on the work for the services of a skilled handworker might be forty cents per hour, while the hourly rate for a large machine tool might be $5 per hour. Furthermore, as the need for accurate costs became still more important, it was also natural to extend this system so as to distribute the total factory cost, if possible. The fundamental principle, then, in the modern machine rate is to assign to each machine its own share of expense for a given period of time. This total expense is then divided by the estimated number of hours that the machine or process will be in use for this same period; this estimate, of course, is based on previous records or some similar source of information. The dividend so obtained is the hourly rate which must be applied to each job using the tool or process. It is clear that a close and proportional allocation of all expenses will be accomplished if each tool and process is in operation during the exact time which has been estimated, and if no additions or deductions are made to the equipment and working force during the period considered. It should be noted that in using this method a machine, in this sense, will be any machine or process from a vise to the largest tool. In fact, as will appear presently, allocation may be made, in this manner, to any place where the work of men involves the use of expense items. The idea underly-

ing this method, therefore, is to measure off *directly* to each "machine," as thus defined, its own share of expense, basing this measurement on the use each machine makes of the several expense utilities, and not on some arbitrarily chosen standard, such as wages or material, which is in most cases only remotely connected with the measurement of these expenses.

14. *Advantages and defects.*—Viewed simply as a means of equalizing interest and depreciation, the simple machine rate may justify its use in some instances; but as ordinarily used as a means of distributing the total expense, it is greatly inferior to the averaging methods already discussed, so far as accuracy is concerned. It will at once be recognized that the allocation of all expenses by machine rate necessitates considerable preparatory work. In a large factory composed of a number of buildings, each building containing machines and processes similar in size and kind, an intelligent allocation of many expenses could be made to each department, and these departmental expenses could easily be distributed by machine rate if certain other difficulties, to be discussed later, could be properly dealt with. For in such a case the departmental expense could be accurately allocated to the building as a whole, and each machine, theoretically, should share equally in this burden. Such conditions are, however, rather rare and it is difficult, if not impossible, in most cases, to secure these conditions by rearrangement of the

equipment. In a small factory, where there are few tools of each size and kind, and where the processes are varied, a considerable difficulty may arise in justly allocating the expense chargeable to each utility. But even in factories of this type it is possible to make a fairly consistent allocation of a large portion of the burden.

It should be noted that, altho a large part of the expense naturally gathers around machines and processes, there are other expenses that do not naturally so attach themselves. Thus, general labor and supervision, crane service, transportation service and similar expenses, are not so clearly assignable by machine rate and may need some form of special determination. But all of the above objections can be more closely met than can the inherent defects of the averaging methods. As will be shown, it is possible, even in complex cases, to work out a machine rate that will be obviously more intelligent than any averaging method. Whether in any particular case it will be expedient, and whether it will pay to do so, will, of course, depend on the immediate circumstances. There is, however, one fundamental defect of the simple machine rate which destroys its accuracy unless special precautions are taken.

It will be remembered that the hourly rate is established by estimating either upon the basis of past experience or upon that of the probable number of hours the machine or process will be in operation during the period considered. Obviously, the accuracy

of the hourly rate will depend on how closely the actual operating time of each machine corresponds with the estimated time. Should a machine be in operation more than its estimated time, as might occur in overtime work, due to a hurry job, an overcharge of expense is made. On the other hand, should the machine fail to operate the full estimated number of hours because of lack of work or a breakdown, an undercharge of expense will be made. It may happen, of course, that these two errors will balance each other, but in general they will not, and there is no definite way of knowing just what the error is. When the volume of work is decreasing the large machines become idle first; this may lead to a serious undercharge which cannot be detected until it appears in the general accounts, too late, perhaps, to remedy the difficulty. Furthermore, it is not possible, as a rule, to estimate in advance just how long any machine will be in operation, even when the records of past performances are available. It is not always possible to wait until the end of the month to find out how long each tool has been used; so that, in general, the estimate of the operating time of any tool or machine must be approximate. The simple machine rate as outlined depends, therefore, for its accuracy on the constancy of all factors, a condition which seldom, if ever, occurs.

Notwithstanding these serious defects, which eliminate the simple machine rate from most of the modern systems, this method possesses one char-

acteristic which is possessed by no other system and which has not only been the means of keeping it alive, but which also promises to make it more important in the future. The machine rate does take into account the difference in the cost of work done on machines of different sizes and by different processes. Some of the relations which it establishes between the machine or process and the work done are fairly permanent and do not vary with the volume of business transacted. For this reason it probably forms a better basis for a cost system than any other plan.

15. *Supplementary rate.*—Numerous expedients have been proposed to make the machine rate more effective. Space will not permit a discussion of all the propositions; in fact, most of them are not important enough to merit much discussion. One of the latest and, in all respects, the most comprehensive effort to adapt the machine rate to modern conditions is that of Mr. A. Hamilton Church. Mr. Church has endeavored to make the machine rate more serviceable by the use of a so-called supplementary rate, the operation of which will now be briefly described. All expenses which can be so allocated are apportioned to machines and processes proportionally. These allocated expense items are charged off by a machine rate, as already described. A record is kept of all such expense so distributed and at the end of the month, or whatever other period has been selected, the total sum of this distributed expense is sub-

tracted from the total shop expense which has accrued during the period. The difference so obtained is, of course, the expense which remains to be distributed; it represents the expense which has not been distributed by machine rate, owing to idleness of the machines, plus all other general shop expenses which cannot be allocated to machines or processes. If all machines and processes have been in operation the exact time used in estimating the machine rate, the undistributed expense will, obviously, consist entirely of general shop expenses. Whatever the content of this residual expense, either it is charged off by one of the averaging methods that have been described over the jobs that have gone thru during the period, or it is distributed as a percentage on the expense already apportioned to those jobs by the machine rate.

Theoretically at least, this method makes the most intelligent allocation of the bulk of the expenses, and with this supplementary rate the total expense will be distributed with as much certainty as by the averaging methods. The supplementary rate serves also as an index to the volume of work in the shop. A rising supplementary rate would indicate lack of work, while a falling rate would indicate reverse conditions. In principle, at least, the machine rate, with the supplementary rate, offers an attractive solution to one of the most difficult problems of cost finding.

It will be obvious, also, that in many cases approximate machine rates can be assigned without

great difficulty. In the general case of mixed manufacturing, however, the assigning of the machine rate requires considerable preliminary work, if any approach to accuracy is to be obtained, and this weakness constitutes the greatest drawback of the method. Mr. Church's plan is so logical, however, that it is discussed more fully in the succeeding chapter.

REVIEW

Why is the question of the distribution of expense burden important?

Using your own figures, how would you distribute expense burden under the following methods:

(a)	Distribution	by	percentage	on	material	cost?
(b)	"	"	"	"	labor	"	?
(c)	"	"	"	"	prime	"	?
(d)	"	"	"	"	man-hours	"	?

What is the inherent defect in all of the above methods, and to what class of enterprise may each method be applied without serious error?

What is the difference between the old and the modern machine rates? What do you understand by the supplementary rate?

What, in your opinion, are the principal defects of these methods of burden distribution?

CHAPTER XI

PRODUCTION CENTERS AND THE SUPPLEMENTARY RATE

1. *General principles.*—The method of distributing expense by the machine rate and the supplementary rate has come into prominence thru the writings of Mr. A. Hamilton Church,[1] who has investigated the plan very thoroly, and whose reasoning presents a somewhat different point of view from that upon which the old averaging methods are based. As a result of this reasoning the shop or factory, instead of being regarded as an organized whole, as in the averaging methods, is regarded as "a collection of production centers, each differing from the other, with certain common connecting bonds," which are the averaged or general factors in the expense charge.

As Mr. Church explains:

> A production center is, of course, either a machine or a bench at which a handicraftsman works. Each of these is in the position of a little shop carrying on one little special industry, paying rent for the floor space occupied, interest for the capital involved, depreciation for wear and tear, and so on, quite independently of what may be paid by other

[1] See "The Proper Distribution of Expense Burden," by A. H. Church; also "Production Factors in Cost Accounting and Works Management," by the same author.

production centers in the same shop. Then, in addition to this, there will be a separate debit representing those items of expense which can be treated only as an average all-round charge.

2. *Production centers illustrated.*—This conception will become clearer if the factory be regarded as consisting of a large number of small productive units, separated physically from each other and supplied with heat, light and power from a central station in such a way that all such services can be measured and debited against each little shop. These little shops will necessarily vary in size and in the size and character of their equipment.

If, now, the owner of this factory should rent some of these little shops to employes and should operate others himself, he would not charge off the operating expense by any system of averaging. He would, necessarily, keep an independent account with each production center so as to be able to show the exact amount of each service (or production factor) that he supplies to each shop. Some of these services, such as insurance, depreciation, taxes and supplies, could be accurately recorded and charged to each center. Others, such as heat, light and power, could not be charged with quite the same accuracy, but still with accuracy enough for all ordinary purposes. Other items of general service, such as transportation and telephone service, might give still greater trouble; yet a fair approximation could be made even in these cases. And lastly, there might be a

small residuum of expense, so general that it might have to be distributed by some averaging method.

The workman renting one of these little imaginary shops would then receive a periodical statement of his indebtedness to the owner. He could add thereto any other expenses peculiar to his work and, by estimating the number of hours during which his machine was in operation, he could compute a machine rate that would discharge all of his expense in the manner already described. By means of a supplementary rate, as previously explained, he could also care for any other expense which could not be controlled in this manner, and also for the difference between the actual and the estimated number of hours during which his machine was in service.

3. *Application to actual conditions.*—It would seem that these conditions do not change simply because the imaginary walls are taken away from these little shops and a large building, housing them all, is erected over them. Mr. Church's argument that this method is the only accurate one of finding costs seems logical. The possible functions of a manufacturer are numerous. He may be an owner or he may be a renter. He may supply his own power or he may buy it. He may furnish his own heat and light, or he may depend on others for these services. Viewing the manufacturer from this standpoint, it is clearly more logical to segregate his expenditures according to functions than it is to segregate them according to the kinds of workmen employed. The workman who

rents one of the little shops discussed above, will be interested, for instance, in the cost of power per kilowatt as measured by his meter, and will not be interested in the average cost of repairs to the entire factory of which the power plant forms a part.

An analysis of all labor expended in a given time, arranged according to the kinds of labor employed, does not, in general, give as intelligent a view of what has occurred as an analysis arranged to show the results of the several activities or functions of the business. There does not seem to be any reason why the manufacturer should not know the unit cost of his power, no matter whether he buys it or produces it himself.

It will be seen, therefore, that the general idea of classifying and distributing the expense according to the functions or activities of the business is decidedly different from that which lumps all expenses together and distributes them uniformly over the entire product. The first classifies all expenses that apply to each activity or service of the business in such a way that this service and its efficiency, or inefficiency, stand clearly revealed. The second and older method throws into one lump all expense of a given kind, without regard to the service rendered, and at best gives nothing more than comparative totals which may or may not be useful. This may be made clearer by considering the problem a little more concretely.

4. *Production factors.*—In discussing the con-

crete case of an actual factory Mr. Church classifies the production factors, or service rendered to production centers, as follows:

a. Land-building factor.
b. Power factor.
c. Lighting factor.
d. Heating factor.
e. Organization factor.
f. Supervision factor.
g. Stores-transportation factor.

These are general factors that serve production centers in varying degree, according to their needs, and they are, in general, the most difficult to allocate. In addition, each center will have certain expense factors which are peculiar to itself, and which arise out of the character of the production center and the work therein performed. These include such items as interest, depreciation, repairs, supplies and all other expenses which obviously are entirely of a local character, and which belong strictly to the production center concerned, bearing no relation to any other machine or process. It remains to consider the practical distribution of these several factors to the various centers. This feature of the plan is here discussed in order to bring out clearly the general principles involved and to show the difficulties to be encountered.

The first step in arranging this system is to lay off the factory into production centers. These centers may include no tools at all, or they may include only one tool, as in the case of the large machines, or they may contain several, as in cases where a number of

tools exactly alike are grouped together. The entire factory must be mapped out in this manner in order that all equipment may be accounted for.

5. *Land-building factor.*—The first factor to be considered would probably be the land-building factor, and the first item under this heading would naturally be the rental of the ground on which the building stands, or the equivalent interest on the investment in the land, if it is owned by the proprietor. To this would be added the rental of the buildings (or the equivalent interest if they are owned outright), and the taxes, insurance, repairs and depreciation on them. The total of these charges divided by the total productive floor area would give the charge per unit of floor area which must be made against each production center.

In making such computations it may be necessary to take into account the use to which different floor areas are put. Thus, space in a high building used for erection purposes, and served by an overhead traveling crane, will be more valuable than the floor space of an adjoining building where three or four floors are used. This difference can be compensated for by charging a higher rate for the floor space in the high-roofed shop in computing the unit space charge as outlined above, and also in computing the total space charge for the high-roofed shop.

In some cases the buildings cover only a small part of the land, the remainder being used for storage or other useful purposes directly connected with the

business; or part of the grounds may be used in an ornamental way for lawns and parks. Again, the ground may be held under still different conditions. Part may be owned outright, part may be mortgaged, or part may be leased. Obviously, no definite rule can be laid down that will cover all cases, and each must be handled according to the conditions existing. In all cases, however, the land-building factor may be measured in terms of floor area.

6. *Power factor.*—The distribution of the cost of the power used may be very simple, or it may be complex. If electric power is purchased and each machine has its own meter, it will not be difficult to apportion the power cost with accuracy. But in the average factory such simple conditions seldom exist. The same set of boilers may furnish steam for operating engines which supply power to the factory, to hydraulic pumps which supply a hydraulic system, and also to air compressors which supply a pneumatic system.

The transmission system may be complex, and it may be difficult to separate its services by departments unless the system has been constructed with this end in view. In addition, a large amount of power may be used in testing new product, as in the case of factories making electrical machinery.

But even in complex cases a division of the total power supplied can be made in a satisfactory manner, tho it may not be absolutely accurate. Evidently, in very complex cases some estimating must

be done; the total output of power of any kind can then be debited to the several centers using it, in proportion to the capacity of the motor or belt which operates it.

As before explained, an estimate must be made of the time each center will be in actual operation. The product of this estimated time and the horsepower assigned to each center gives the horsepower hours which each center is expected to use. The total horsepower hours developed, divided into the total cost of the power, will give the rate per horsepower hour that must be used in distributing the power expense. The total cost of any one kind of power must include depreciation, repairs, fuel, etc., and the interest on that part of the power plant which supplies the power.

7. *Lighting factor.*—The general method of apportioning the lighting expense would be similar to that pursued for the problem of power, in so far as allocating the total cost to any one building is concerned. The total cost of lighting that is assigned to any building, divided by the total floor area of the building, as in the case of the building factor, will give the total charges per unit of floor area, and the amount that would belong to each production center may be found by multiplying this unit charge by the floor space assigned to the center. Due care must, of course, be taken that interest, repairs, depreciation, etc., over the entire lighting equipment are equitably distributed to each building so far as

possible, as well as that the actual cost of the gas or electricity supplied is accurately estimated.

8. *Heating factor.*—The problem of heating and ventilating is very similar to that of lighting, the cost being reduced to a charge per unit of floor area. These items, as in the case of lighting, are not constant the year round. Thus, heating may be required during only a few months of the year. It would not be good policy, however, to charge off these heavy expenses during the months they are incurred. The total cost of heating and ventilating the factory is, therefore, spread out over the entire year, lighting being treated in a similar manner.

It would appear, therefore, that even in this method of distributing expense, some averaging must be resorted to; exact distribution in point of time would not be desirable. It should be noted, however, that this averaging is within the service itself. It simply equalizes the service charge over a period of time, differing in this respect from the old averaging methods, which average all services over all activities, regardless of the use each activity has made of such services.

9. *Organization factor.*—Under the term organization factor, Mr. Church includes such elements as the building factor of factory offices, cost of time and cost keeping, factory office expenses, wages of watchmen, interest, and depreciation and repairs on office furniture and fixtures. There is no difficulty in obtaining the yearly and monthly totals of these items

and it only remains to assign this total by machine rate.

In a very large establishment which is highly departmentized this total could be apportioned to the several departments with a fair degree of accuracy; but after such an apportionment is made for a large plant, and always in the case of a small factory, further allocation, based on services rendered, would be difficult. It is sufficiently accurate, however, to distribute these departmental totals by simple division over the production centers involved. The cost of this class of service is not, in general, affected by the size or weight of the parts handled. It costs as much to put in a production order for a small part as it does in the case of a large one. This method will, therefore, be substantially correct. The result obtained by dividing the total organization expenses by the number of production centers involved, will give the factor which may be included in the machine rate to cover these expenses.

10. *Management and supervision factor.*—The management and supervision factor will include the wages of superintendents and foremen, cost of inspection, the building factor of such offices as pertain to supervision, and the interest, depreciation and repairs incident to the equipment involved. Brief reflection will show that there is no fixed or best way for allocating this expense; the method used must vary with the circumstances. In other words, the element of judgment must enter into the distribu-

tion of this factor. Many of the items can be localized without trouble, and when this has been accomplished the remainder should be distributed after a careful survey has been made of the relative value of the services which they have rendered.

11. *Stores and transportation factor.*—The last factor, stores and transportation, is by far the most difficult to apportion. This factor will include the cost of storing, handling, and transporting material during manufacture. It will not include freight and cartage of finished product chargeable to material account, or such items as the handling of coal and ashes, which belong in the power-house accounts.

Mr. Church has pointed out that the storing of materials, moving them from stores to shops, and from machine to machine, constitutes a separate and distinct service that should be accounted for separately and charged for in proportion to services rendered. It is true, also, that the efficiency of the factory is measured largely by the efficiency of the system of stores and transportation; hence comparative costs on this class of service would be valuable, aside from their use in cost finding. Mr. Church has also noted that this factor is divisible into two parts—the cost of storing materials and the cost of moving materials. It should also be observed that the allocation of this item cannot be made on the basis of the value of the materials handled unless the material is all of one kind. It costs no more to handle brass castings than it does to handle wooden articles. Bulk or weight must be the basis for such allotment.

Furthermore, it can be easily seen that there is no fixed rule or method by which this apportioning can be accurately accomplished; it is principally a question of judgment. In a shop doing mixed work in an intermittent manner very accurate allocation of this item is impossible.

In this item, however, if due care is taken, the cost of the general stores can be allocated to departments, the cost of the transportation service can be localized as far as possible, and the items of general utility can also be apportioned as good judgment may dictate. Even such a disposition of these expenses will be fairer than that obtained by the averaging method, which taxes all activities equally. When the totals have been allocated to each center, the amount chargeable against each can be reduced to an hourly rate and included in the machine rate as before.

12. *Individual factors.*—In addition to the general factors that have been discussed there will be, as has been noted, certain expenses that are directly connected with each production center itself, and which have no connection whatever with other centers. Thus, repairs, interest on the value of the machinery, depreciation, insurance, and such supplies as may be necessary for operation, may be mentioned as examples of these individual factors. In some cases the cost of tools or attachments might be included in this charge. Obviously, the totals of these items can be reduced to an hourly charge which can be included in the machine rate. The relation between deprecia-

tion and repairs requires no further comment except to point out that a careful distinction should be made between repairs that add to the producing value of the centers and those that simply replace wear and tear.

13. *Controlling accounts.*—It will be evident that some means must be provided for insuring that the total cost of each service is properly distributed as the expenses rise and fall, and that the supplementary rate absorbs the residue. In all averaging methods the same care must be exercised with regard to the totals of all expenses. To accomplish this, Mr. Church advocates the use of control accounts, an account being kept for each factor. All accruing expenses of a given kind are carried to the proper control account and placed on the debit side. All expenses distributed are placed on the credit side. The difference, if any, indicates the change which must be made in the machine rate to obviate discrepancies. Clearly, such controlling accounts can be used with advantage for equalizing heavy expenses over definite periods of time.

14. *Assembling of production factors.*—The foregoing discussion of production factors is based largely on Mr. Church's reasoning, and is introduced particularly to show the character and the difficulty of the problem rather than to offer specific methods of solution. It may be well, however, to note some methods for collecting these factors into concise and usable form. Evidently the problem is complex and

should be undertaken systematically. Figure 14 shows a form suggested by Mr. Church,[1] and ar-

SCHEDULE OF ______ AND MACHINE RATES				SHOP FACTORS			
1	DESCRIPTION						SHOP TOTALS PER ANNUM
2	MACHINE NO.						
3	SPACE OCCUPIED						
4	POWER ABSORBED						
5	CAPITAL VALUE						
6	DEPRECIATION RATE						
7	BUILDING FACTOR						
8	POWER FACTOR						
9	LIGHTING FACTOR						
10	HEATING FACTOR						
11	STORES-TRANSPORT FACTOR						
12	SUPERVISION FACTOR						
13	ORGANIZATION FACTOR						
14	INTEREST, DEPC'N & INSR'CE						
15	REPAIRS & MAINTENANCE						
16	OIL AND ALLOWANCE						
17	TOOL ROOM CHARGE						
18	YEARLY TOTAL FOR 2700 HRS.						
19	HOURLY RATE						

FIGURE 14. SCHEDULE FOR DISTRIBUTING EXPENSE ACCORDING TO PRODUCTION FACTORS

ranged for the convenient collection of these items. A schedule like this may be provided for each shop or department, and there should be a vertical column

[1] See "Production Factors," by A. Hamilton Church, p. 128.

for every production center in the shop. The total hourly rate then may be found for each center by dividing the total of all charges by the total hours of operation.

While comprehensive, so far as the detail is concerned into which the production factor idea is carried, this form is arranged for recording the final values only and does not assist materially in actually computing these values. An examination of Figure 15 may be of service, therefore, in the application of the foregoing methods. Figure 15 shows a hypothetical analysis of this problem, made by Mr. Sterling Bunnell[1] and reproduced from his work on "Cost Keeping," with minor changes to make its discussion clearer. The example selected is drawn from a small shop, with one high story housing the larger tools, and an adjoining two-story building housing the smaller tools. The high story is equipped with a traveling crane. Mr. Bunnell illustrates several good approximations and other means by which the detail of the method may be shortened without materially affecting its accuracy. A brief study of this tabulated statement will make the possibilities of the method more real.

In the table, the first column, reading from left to right, contains the number of the production center. This number may be attached to the production unit in any convenient manner that will make identification sure and easy. The second column contains the name and the size of the unit. The third and

[1] See "Cost Keeping," by Sterling Bunnell, p. 152.

fourth columns contain the single-story and two-story floor space allocated to each production center. The fifth column gives the value of the equipment in each center. The sixth column gives the estimated life of the asset, taking obsolescence into account. Column seven gives the estimated average horse-power required to operate the unit, while column eight gives the estimated number of hours during which the machine or production center will be in use during the month. These latter values must, of course, be established by estimate unless means are provided for measuring the power consumed over a considerable period of time; but if estimated, their total should check with the total power developed. Column nine gives the horsepower hours used by each unit, found by multiplying together the corresponding values given in columns seven and eight. Column ten contains the monthly charges for depreciation. This is found by multiplying the figures in column six by twelve in order to reduce the estimated life of each productive center to a monthly basis and dividing this into the values given in column five. It will be noted that this is the straight line method explained in chapter nine. Columns eleven and twelve contain the monthly charges for insurance and interest respectively. Insurance is computed at the rate of eighty-five cents per year on each one hundred dollars of value making approximately seven cents per month. Interest is figured on a yearly six per cent basis.

No.	NAME OF UNIT	Square Feet		Value in place	Estimated Years	Estimated H. P.		
		One story space	Two story space				Hrs.	
1	Lathe 18″ x 10″............	120	......	600.00	15	1	240	
2	" 24″ x 14″............	152	......	900.00	15	1½	200	
3	" 32″ Chucking........	320	......	3200.00	10	5	180	
4	Cylinder Borer............	......	240	1800.00	15	3	200	
5	Radial Drill 48″..........	......	160	900.00	12	1½	240	
6	" " 72″..........	......	192	1300.00	12	2	200	
7	Heavy Upright Borer.......	......	192	800.00	12	2	200	
8	Lathe 32″ x 16″............	......	207	1700.00	18	5	150	
9	Open-Side Planer..........	......	358	3700.00	20	7	200	1
10	Boring Mill 72″...........	......	266	3000.00	20	5	180	
11	" " 30″...........	......	126	1200.00	15	3	240	
12	Hor.-Slab Mill.............	......	161	1300.00	10	5	200	1
13	Assembly 8 Men...........	......	2323	400.00	2	5	1950	*1
14	Patt. Shop 2 Men..........	600	......	2100.00	15	1	500	
15	Turret 2″ x 24″............	216	......	1400.00	10	2	220	
16	Screw Machine.............	150	......	500.00	10	1	240	
17	Fox Brass Lathe...........	130	......	400.00	10	½	100	
18	Drill 30″..................	110	......	200.00	15	1	240	
19	" 30″..................	110	......	200.00	15	1	240	
20	Lathe 16″ x 8″............	160	......	400.00	15	1	240	
21	" 16″ x 10″...........	180	......	450.00	15	1	240	
22	" 24″ x 8″............	240	......	850.00	15	1½	220	
23	Miller No. 4 Univ..........	144	......	1050.00	12	2	200	
24	" No. 2 "	144	......	700.00	10	1	240	
25	Shaper.....................	180	......	700.00	15	1½	200	
26	Vises 6 Men...............	1000	......	300.00	2	2	1450	*
	Totals...............	......	......	....	......	......	8710	..
	Power Plant...............	1100	......	2600.00	20	......	......	..
	Tool Room................	780	......	3000.00	15	......	......	..
	Total Working Space........	5836	4225	....	......	......	......	..
	Total Depr. and Sp. Charge.	......	......	....	......	......	......	..
	Total H.P. Hrs. and Cost...	......	......	....	......	62½	......	13
	Column Number...........	3	4	5	6	7	8	

* Per man basis (incl. crane power)

Figure 15. Burden Distribut

The unit space charge, column thirteen, is found by dividing the interest on the building and ground, or the rent charge for them (in this case taken at 10 per cent on $18,000, or a total monthly charge of $150), by the total area, after doubling the area of the high-story building. This gives approximately 1.1 cents per month per square foot of space for the low-story floors and 2.2 cents for the high-story. Multiplying the areas in columns three and four by the proper respective rate gives the values shown in column thirteen.

Heat and light are considered together since they are both distributed on the basis of square feet of floor space. The rate, two and one half cents per square foot, was formed by dividing the total monthly expense for heat and light by the total floor space. Multiplying the amounts in columns three and four by this rate gives the charges listed in column fourteen.

The total expense for power including space charge, depreciation, etc., divided by the total horsepower hours developed (see bottom of columns fifteen and nine) gives the cost per horsepower hour as two cents, nearly, and multiplying the items in column nine by this rate gives the amounts listed in column fifteen.

Columns sixteen, seventeen and eighteen list the respective items of repairs to machinery, repairs to small tools, and general labor and supplies that are chargeable against each center. These items can be

allocated by judgment until such time as accurate records can be obtained, care being taken that the total of each kind of expense is covered by the allotment. In small shops these items can, no doubt, be apportioned accurately enough by judgment.

The totals of the items in columns ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen and eighteen opposite each unit are then totaled and carried to column nineteen. These totals in column nineteen represent the monthly cost of operating each unit. Dividing corresponding items by the estimated number of hours of operation gives the hourly rates listed in column twenty. All remaining items of expense not provided for are converted into a monthly total and divided by the total hours worked by all productive units, giving a rate of three cents per hour for every production hour, as indicated in column twenty-one. This supplementary amount, added to the corresponding items in column twenty, gives the total burden rate which should be charged for the use of each productive unit.

It is evident that these rates are only approximately accurate. It will be logical and much more convenient, therefore, to express them in even figures. Furthermore, it will be more convenient if all rates which are nearly alike are grouped together and an average rate taken for the group; in this manner the number of rates is reduced. This has been done in the above example, and column twenty-two gives the final readjusted rates. It will be noted

that some of the smaller rates have been increased to make them carry a little more of the burden, and all rates have been rounded off so as to make computations simpler, and also so as to make as few groups of rates as possible. If it is desired, these groups may be designated by letters and each unit may be given the letter corresponding to the group in which its rate is found. The time cards sent in from each center may then bear the letter identifying the rate assigned to it; in this way the computation of the expense chargeable against each job is greatly facilitated. The operation of the plan then becomes identical with the operation of any machine rate with the supplementary rate, but obviously the results produced are much more intelligent. This illustration, while it does not possess the refinements of the complete plan as outlined by Mr. Church, is very useful in showing how the method may be modified to suit small shops, or other plants, where a compromise must be made. With all the modifications and approximations suggested it is evident that costs obtained by this method will be much more equitable than those obtained by the averaging methods.

15. *Inherent difficulties and errors in applying modern machine rates.*—The manifest advantages of this method are offset, to some extent, by the great amount of preliminary work and study necessary to instal the method in plants of large size or complex character. If the plant is built and laid out with the

cost-finding problem in mind, the work will be greatly lessened, and there is no doubt that this feature of factory management will influence, in no small degree, the construction and arrangement of future industrial plants where many and varied products are to be made. The application to complex existing plants is difficult, as before noted, and can be accomplished only by a liberal use of good judgment. Nevertheless, as has been pointed out, even these difficulties are not insuperable in most cases.

Moreover, in comparing the accuracy of the distribution of expense by this method with that of the averaging methods, it should be noted that some of the production factors of the new method are themselves based on averages. Thus, buildings are not heated and lighted equally all the year round, repairs on all kinds of apparatus are not proportional to elapsed time, and expense material may be bought one day that may not be used for several months. These variable factors of expense must be spread out over more or less arbitrary periods of time, if costs are to be consistent. Again, the expenses that have been incurred during the time a job has been under construction are not always definitely known. If all jobs could be started on the first day of the month and shipped on the last day, it might be possible to allocate with some degree of accuracy the identical expense incurred by each job. Evidently, such conditions seldom, if ever, exist. Work must be started whenever necessary, and shipped and billed as soon

as possible, and both production factors and supplementary rates must, in general, be based on previous performances. Usually the record of the previous month is used for rate-setting, but some expenses may have to be distributed over longer periods to prevent costs from being erratic. Any claims for great accuracy made by the advocate of any method of distributing expense should be discounted liberally, unless the conditions are so simple that the interpretation of all the factors involved can be clearly seen.

An objection often raised against machine rates in general is the penalizing effect on small work which is done on a large machine. It often occurs, especially when work is scarce, that work is done on a machine considerably larger than is actually required for the process. Under the machine rate method of distributing expense, a job fabricated in this manner receives a much larger share of expense than when the work was done on a machine exactly suited to the operation. Accordingly, the job is penalized more heavily perhaps than the market price can bear. Furthermore, most records so made are misleading and if not properly interpreted when used for future estimates are likely to make quotations too high. This is, however, a management problem entirely, and with proper production planning methods, there should be no reason for such occurrence.

While these disadvantages hold true, the fact remains that the costs obtained by the machine rate method are really closer to the truth than those ob-

tained by averaging methods which make no distinction at all as regards the varying size and cost of the equipment employed. In practically any factory, the type of machinery and equipment will differ more greatly than will the type of the product. The machine rate not only considers the difference in cost of operating the different types of machinery, but can serve as an index of efficiency of operation and thus call to the attention of the manager weaknesses in manufacturing equipment, or the pressing need for more work of certain kinds.

When the saving that can be made by using special equipment for even a short period of time has been fairly estimated, the expected results obtained thru the difference in labor or other indirect expenses possible thru the operation of an improved machine over the cost of production under ordinary circumstances will not vary greatly from the original estimates. This can be taken care of in the hourly rate for machines that are not used frequently. It increases the cost per hour but does away with the large supplementary rate.

Fluctuations of this rate are particularly large in dull times for then the large machines and processes which normally distribute a large part of the expense because of the high machine rates are the first to become idle when business falls off, and the very last to resume operations when business revives to an extent which would make it economical to operate these

larger machines, which can operate efficiently only on large scale production.

This particular feature of factory work is, however, the cause of one of the most difficult of all cost finding problems in factories where there is a larger variety in cost finding equipment and where several lines of product are manufactured. The effect of the volume of work in expense distribution is an important one and will be discussed in greater detail in the next chapter.

REVIEW

What do you understand the term "production center" to mean?

If a manufacturing company owns its plant-land, and maintains a power-plant building, an office building, a factory and a warehouse, what would be the production factors and of what would the elements of each factor consist?

What are the defects of and objections to production factors and the supplementary rate?

Could you prepare without reference to the text a set of instructions to a cost clerk explaining in detail the method of operating controlling accounts for expense?

What is the basis for the distribution of each of the production factors?

CHAPTER XII

EFFECT OF VOLUME OF WORK ON EXPENSE DISTRIBUTION

1. *Variation of expense with volume of work.*—It is a fundamental principle in all the methods of distributing expense that have been discussed, that the *total* manufacturing expense should be kept constantly distributed in the costs as fast as it accrues. The only exception to this principle that has been noted, is in the case of heavy periodic expenses, like taxes, heavy repair expenses, or purchases of large quantities of supplies, like coal, for example, where such periodic expenses are distributed over the entire year by means of suspense accounts (see Section 3, Chapter VII). If the amount of these periodic expenses that is thus distributed is considered as belonging to the week or month to which it is assigned, the general principle noted in the foregoing treatment holds strictly true for all of the methods discussed.

It appears, therefore, that where this procedure is followed, the cost of production of any given article will vary as the volume of business passing thru the factory changes, since expenses do not vary proportionally with the volume of production (see Section 2, Chapter VII). A considerable increase can be made in the volume without necessitating much, if

any, addition to many expense items; while, on the other hand, a considerable decrease may occur in the volume of work without lessening many of the expenses, and, in fact, before it is possible to reduce them to any great extent. Therefore, where all expense is distributed as it accrues, a rise in the volume of product results in a decrease in manufacturing costs; while a decrease in the volume results in an increase in cost. The phenomenon is only too familiar to all who have had experience in factory supervision.

2. *Illogical increase in expense.*—When a factory is running at normal capacity, and care has been exercised to allocate the burden to each article, in proportion to the use that has been made of the facilities of the shop in producing it, the comparative costs of all articles should be fair and logical. If the output is increased, and all costs of production decreased, no line of production can suffer thereby. But should the volume decrease, the case is different. Suppose, for instance, that the volume decreases so that all the large tools are idle and the lines of product on which they are normally used are no longer produced. Under all of the methods of expense distribution that have been discussed, the expense incident to these large tools when idle is distributed against lines of product that make no use of these machines. This is true even in the production-center and supplementary-rate method, the supplementary rate being introduced for the very purpose of collecting expenses

due to idleness and distributing them over the product in process.

Logically, it would seem that any product should bear only the expense incident to its fabrication. Thus, if a manufacturer owned several factories situated in different towns, he would not think of distributing the expense incident to a factory that happened to be idle against the cost of production in the factories that were operating. There would seem to be no reason for doing so, even if the factories were situated in the same yard and were operated under the same superintendent. By similar reasoning, in a factory consisting of several independent continuous processes, it would not appear to be logical to charge the expense incident to an equipment that was idle against those that were operating. In factories of the intermittent type, operating on mixed work involving a large variety of sizes, such clear-cut distinctions as those noted in the foregoing examples are usually not possible, since it is difficult, in such plants, to segregate work and equipment into classes. Yet the principle involved is so important as to merit special attention.

3. *Errors in costs under averaging methods.*—The degree of errors in the costs under the averaging methods of distributing expense will, because of variation in the volume of work, depend on circumstances. If the machines and equipment do not vary greatly in value small variations in the volume of business will not introduce serious errors in the cost

because of idle machinery. In departments where there is considerable difference in the size and cost of equipment, however, the error thus introduced into the costs may be very great. This is especially true in such cases for the reason that when the volume of work diminishes the larger and more expensive equipment is the first to be left without work and it is also the last to resume operations as business improves. Since the fixed expense belonging to the larger equipment is, in general, much larger than that belonging to the smaller machines, the latter may have an expense burden laid upon them which is prohibitive to sales. And even when the equipment does not vary greatly in size or value, and there is a marked decrease in volume of business, considerable illogical distribution results with the averaging methods of expense distribution.

4. *Errors in costs under the supplementary rate.*—It will be noted that the production-center method aims to allocate all expenses to each machine and process in such a way as to make it possible to charge every piece of work in proportion to the use it makes of the manufacturing facilities. So far as this allocation is concerned, the production-center method is in accord with logical expense distribution; but the supplementary rate is not logical, in so far as it distributes expenses belonging to one machine or process against the cost of operating some other machine or process. The defense of such a procedure in connection with the supplementary rate is the same, of

course, as that made for the averaging methods, namely, the assumed necessity of distributing all expense as fast as it accrues. It is held by some that this necessity does not exist, and that such complete distribution may often be bad cost accounting, since when the volume of work is greatly decreased, this procedure may make the cost of the product that is in process so high as to make selling prohibitive.

5. *Responsibility for costs.*—It was shown in Chapter III that one of the fundamental functions of a cost system is to show clearly the expense items for which each departmental head is responsible, and, following this procedure, it is customary to hold the factory superintendent responsible for manufacturing expense. It does not seem fair, however, to hold the manufacturing superintendent responsible for expenses due to idle equipment since he is in no way to blame for such idleness; nor does it seem fair to include the expense of idleness in current costs since obviously they confuse and distort such costs with changing volume of business. It has been advocated, therefore, that the expense distributed against any product should be strictly proportional to the use it has made of the manufacturing facilities; and that any other expense belonging to any other product or equipment should be disposed of in some other manner. It may be of interest to review briefly the several plans that have been suggested to obviate this difficulty.

6. *Mr. Gantt's solution.*—Mr. H. L. Gantt, dis-

cussing this problem in an interesting paper[1] presented before the American Society of Mechanical Engineers, argues that "the indirect expense chargeable to the output of a factory bears the same ratio to the indirect expense necessary to run the factory at normal capacity, as the output in question bears to the normal output of the factory." That is, if the production falls to, say, one-half the normal volume, this production should be burdened with only one-half the normal expense so that, everything else remaining the same, the manufacturing costs would not change with change in volume of product. The undistributed expense would be charged to the profit and loss account. Granting that proportional distribution is correct in theory, Mr. Gantt's statement is strictly logical only when the decrease in volume of product is brought about by the complete suspension of production in some lines, while the remaining lines are continued at normal volume. Mr. Gantt's theory will hold approximately true also for moderate decrease in all lines. But if a great decrease in volume takes place in all lines, which often happens, a rise in productive prices will result from causes which lie in the nature of the expense itself that rightly belongs to every line. As explained in Section 2, Chapter VII, expense, in general, does not vary directly with volume of output, but becomes greater in proportion as the volume decreases, since, in practically

[1] See *Journal of the American Society of Mechanical Engineers*, August, 1915, p. 466.

all expense, there is an irreducible minimum that must be cared for, no matter how small the output may be. There is therefore a minimum volume of product that can be manufactured profitably, and beyond which it may be disastrous to continue.

7. *Fixed and variable expense.*—The characteristics of expense that have just been referred to should be carefully noted since they have a large bearing on the question under consideration. As has been explained in Section 2, Chapter VII, expense is of two kinds, namely, fixed and variable. Fixed expense is that due to the existence of the enterprise and it does not vary in value to any marked degree for any given equipment. The value of fixed expense can never become zero and there is an irreducible minimum value below which it cannot fall. Variable expense on the other hand may vary from zero thru a wide range, depending on the volume of business that is transacted. An investigation of a number of factories by Mr. N. T. Ficker indicated that fixed or constant expense averaged 40 per cent of the total expense during normal operating conditions. The effect of constant expense in distorting the costs increases, therefore, as the volume of work diminishes. It should be noted that the expense that is distributed by the supplementary rate is composed principally of fixed expense, and therefore if there is much error in estimating the probable time of operation of the several machines and processes the supplementary rate may greatly distort the cost in dull periods.

8. *Mr. Ficker's solution.*—With these characteristics of expense in mind Mr. Ficker[1] has proposed that "the expense chargeable against the shop should be that portion of the constant expense which the current activity is of the normal activity, plus the actual current variable expense." That is, if the activity of the enterprise for a given time is found to be 70 per cent of the normal activity, the expense which should be charged against the manufacturing or producing department should be 70 per cent of the constant expense in normal times, plus the actual variable expense that is justly chargeable against the actual productive operations for the period. Mr. Ficker's plan appears to be very logical tho there are some aspects of the matter that should be considered further. Mr. Ficker would carry all undistributed expense to a separate account and dispose of it either by discharging it thru the costs during periods when the manufacturing activity was above normal or by charging it to profit and loss.

In judging of the merits of this plan it should be remembered that under any of the averaging methods of expense distribution the entire expense, fixed and variable, is charged against current production. But the supplementary rate burdens current production only with that fixed expense that is not distributed because of error in estimating the machine rate. If the estimated time of operation of each machine and process agrees closely with the actual periods of

[1] See "Shop Expense Analysis and Control," by Nicholas T. Ficker, p. 129.

operation the machine rate will absorb the fixed expense belonging to each machine, and a large part of the variable charges; and the error introduced into the costs because of decrease of business may not be great under this method. The great difficulty in operating the supplementary rate is in estimating accurately the periods of operation, keeping in mind great periods of depression in business. For this reason there will probably be periods in every business when there will be a considerable amount of undistributed expense that does not logically belong to current production but which must be accounted for in some manner.

9. *Disposition of undistributed fixed expense.*—Two methods of solving the problem of undistributed expense have been proposed in the foregoing. The first plan is to carry all expenses due to idleness, directly to the profit and loss account and charge them off as a loss against the business. The error in the reasoning which is back of this plan is that it assumes that all expense due to idleness is irrecoverable, an assumption that is not necessarily true. A machine may be indispensable and yet be idle a considerable portion of the time, and the expense charge for the machine should be set so as to discharge the total yearly expense over the production for that period. If expenses due to idleness are carried to the profit-and-loss account, the corresponding expense that is discharged when the machine is in operation should also be carried to the same account as a credit,

if the usefulness of the machine, and of the line of product produced upon it, is to be judged correctly.

The other plan is to carry all expense to an expense account and distribute it by one of the averaging methods discussed in Chapter X, but to adjust the rate of distribution according to the experience of an entire year, at least, instead of according to the records of the preceding month. The expense account, therefore, will act as a reservoir, discharging more of the expenses in busy periods and fewer of them in dull times. It will, of course, also equalize periodic expenditures, such as taxes, etc. If the rate of discharge is accurately set the entire expense should be discharged at the end of the period for which the rate of discharge is computed. Should there be an undistributed balance in the account at the end of the fiscal year, it can be carried to profit and loss, or it can be carried forward into the next period and the rate can be adjusted so as to distribute it over that period. While this method provides for distributing all the expense without great danger of unduly overburdening production during dull times, it is, of course, open to the same objections that have been urged against all averaging methods (see Section 10, Chapter X).

It would appear, however, that an intelligently computed machine rate, like that discussed in Section 13, Chapter X, in connection with a supplementary rate based on a long period of time, would do much to solve this perplexing problem. The machine rate

would distribute all expenses that are attached to the machine, or process, in proportion to the use that is made of it, irrespective of the volume of product. The bulk of the costs would, therefore, be proportionally distributed except in periods of great depression when, as has been noted, practically any method is of doubtful accuracy. The supplementary rate, containing the expense due to idle time, would be equalized not only over processes, but also over periods of prosperity and of depression; thus the danger of overburden during dull periods would be obviated. This method possesses many virtues that recommend its trial in practical cases where machine rates are appropriate.

10. *The problem of the manager.*—Furthermore it should be remembered that while the costs should be logical and should be just to the manufacturing organization, the manager has the task of making the business pay dividends. It must be remembered that any expense that is not included in costs and recovered in the sales price is a loss. Expense cannot be carried to some account and disposed of any more than it can be safely forgotten. Entirely aside from any logical principles of expense distribution, expediency would dictate that as much expense as possible be buried in the sales price, regardless of the origin of these expenses. It would be obviously foolish, however, to overburden an active line of production with the expense of inactive lines to such an extent that sales would be impossible; this

would seem to be the only danger from a procedure of this kind.

In any case, therefore, the manager should have constantly before him a statement of all undistributed expense. If he can dispose of some of it by raising the prices of active lines of work and still retain his market, no reasonable objection can be raised to doing so. If market prices forbid such a procedure he will be constantly reminded of the necessity of increasing his sales to the point where this undistributed expense will be absorbed in costs. Only when these efforts fail should undistributed expense be carried to profit and loss, and, obviously, if enough of such expense is thus disposed of, the business will become insolvent.

The entire question of variation of expense burden with change in volume of product is interesting, tho complex. It is unwise to make sweeping generalizations regarding a solution; in fact, it is unwise to generalize regarding any problems in cost finding. This phase of cost finding, which has just been discussed, will bear close inspection by managers whose volume of production varies markedly.

REVIEW

What is the effect of decreased production upon costs? How would decreased production affect a factory with several independent continuous processes?

How would you deal with the problem of idle time in a factory?

What are the salient features of the different methods of disposing of undistributed fixed expense?

Why should the manager of a factory be especially concerned with the analysis of expense?

CHAPTER XIII

OTHER FEATURES OF EXPENSE DISTRIBUTION

1. *Basis of expense distribution.*—It will be evident that many enterprises cannot introduce such comprehensive methods of expense distribution as have been described in connection with the production-center method in Chapter XI. Furthermore, as has been noted, there are many places where such detailed methods are not necessary and where simpler systems will suffice. There are several points, however, that are made very clear by the discussion of production centers that apply to all methods of expense distribution.

Thus it is made clear that the correct basis of distribution of rent, insurance, taxes, repairs and depreciation is time. It is clear, also, that such expenses as power, light and heat when applied to actual productive operations are logically distributed on a time basis thru a machine rate. But it is shown that expense involved in handling, storing and transporting material in the factory should be distributed, not on a time basis, but acording to bulk or, since bulk is difficult to measure, by weight which approximates bulk. It should be noted in this connection that heat, light and power may be necessary in this

transportation factor, so called, and, therefore, those parts of these expenses that belong to the transportation factor should be carefully separated from those that belong to productive activities since the basis of distribution is different.

2. *Application to averaging methods.*—Such segregation of expense as has just been indicated is inherent in the production-center method but the general principles involved are applicable to other and simpler methods. Thus in distributing expense by the percentage-on-labor method it is illogical to include the storeroom labor and transportation expense in such distribution but the latter should logically be applied in an independent manner on the basis of weight. This procedure would separate all factory expense into two parts on the basis of the method of distribution. Following Mr. Church's nomenclature in Chapter XI these divisions may be called production expense and transportation expense. Mr. Ficker has used the terms machine expense and material expense to denote these divisions.

The content of transportation expense should be carefully noted. As outlined in Section 11, Chapter XI, this item should include the cost of storing, handling and transporting material, the wages of inspectors and storekeepers, etc. Logically it should not include such expenses as insurance and depreciation on material since these are not accurately distributable by bulk but are based on the value of the material and involve the element of time. Such items are

best handled, perhaps, by distributing them against the value of the material before issuing it from the storeroom. See also Section 9, Chapter V.

3. *Application and limitations.*—Suppose therefore that under the percentage-on-labor method of distribution it is found that the production expense is 75 per cent of the productive labor cost and that the transportation expense is found to be ½ cent per pound. A certain job is found to require $40 of direct labor and 500 pounds of material worth 2 cents per pound. The shop cost will then be

Material	$10.00
Transportation expense	2.50
Direct labor	40.00
Production expense	30.00
Total	$82.50

It should be noted, however, that the necessity of thus separating the factory expense should be apparent before such a step is taken. In many factories the transportation factor is a very small one, and it will be sufficient to charge all storeroom expenses against the material before issuing it. On the other hand there are industries such as structural plants where the transportation factor is so large as to merit the special consideration discussed in the foregoing even under percentage methods of distribution.

4. *Verification of expense distribution.*—It was shown in Section 3 of Chapter VII that it is not possible, generally, to allocate the actual expense that is

incurred in doing a given piece of work but that this expense must be distributed on the basis of past experience. The percentage rates used in any of the averaging methods of expense distribution and the machine rates of the production-center method must always be calculated on the basis of values obtained in some prior period of production. Since conditions in any enterprise vary constantly it is clear that all distribution rates should be checked constantly.

A record should be kept, therefore, of all expense distributed during the accounting period which is used as a basis of calculation, and this should be checked against the estimated expense that has been used in setting distribution rates, and such adjustments should be made in these rates as will correct any differences between the actual and the estimated expense. The degree of detail to which this comparison may be carried will, of course, depend upon circumstances. In any of the averaging methods there is little use in checking beyond the totals for each department for which a rate has been set. In the production-center method, however, it may be necessary to investigate and correct each machine rate if accuracy in the costs is to be maintained.

5. *Continuous-process costs.*—In continuous processes, or, in other words, where, owing to the conditions of manufacture, the lots of material follow each other in such a manner that the workmen cannot distinguish one lot from another, the production-order method does not apply, and the system of arriving

at cost must be different from that of the outline given, tho the fundamental principles are the same. A consideration of a simple case, such as that of a cement mill, may make the general method clear. Here the material flows in a continuous stream thru the several processes, and the output is more dependent on the machines than on the workmen. The material, moreover, passes thru all of the machines, so that the mill, so far as finding total costs is concerned, may be treated as a single machine. The problem is still further simplified in this case by the fact that the material in process at any one time is not of great value as compared with the monthly output, and therefore can be neglected in computing costs. Furthermore, the material passes thru the mill rapidly, and at no time is there a large amount of labor tied up in work in process. It is evident that all that is necessary, so far as total costs are concerned, is to find the total labor and expense incurred during a given period, and divide this total by the output for the same period; this output may be expressed in terms of weight or bulk; that is, in terms of pounds or barrels. The dividend so obtained will be the amount which must be added to the material cost of each unit of output to cover the labor and expense of production. Obviously, these computations can be made more frequently than in the case of the more complex production-order methods.

6. *Detail-process costs.*—If it be desired to know the cost of each process, or department, of a continu-

ous-process industry, labor and expense costs must be kept by processes or departments, but they may be distributed, as before, by simple division on a material basis, and this will indicate the general method to be pursued in more complex cases. It is usual in such cases to issue a standing-order number to each process, and to charge to this number all labor and expense, if the latter can be segregated. The total amount of these items for any period, divided by the total weight or volume of all of the manufactured product passed thru the process for the same period, will give the unit cost which must be charged against each unit of material that has passed thru the process. If the expense cannot be allocated to each process, the unit labor cost can be ascertained as indicated in the foregoing treatment, and this cost can be used as a basis for distributing the burden of expense to each unit of product.

Thus, in a factory consisting of several simple continuous processes, each process involving a separate and distinct series of machines, it would be difficult, in general, to segregate accurately all of the expense; hence compromise methods, like those described in Chapter X, may have to be employed in such cases for allocating the expense.

7. *More refined process costs.*—The discussion in Sections 5 and 6 of this chapter assumes that the material passes rapidly thru the process, or series of processes, and that, therefore, the labor and expense collected at the end of the week or month, as the case

may be, belong, approximately at least, to the material that has passed thru during that period. If, now, the time required to pass the material thru the process, or series of processes, is considerable, this assumption does not hold true, but part of the labor and expense collected at the end of the accounting period will belong to the material that has passed thru, and the remainder will be chargeable to material in process. The longer the period of fabrication, as compared to the accounting period, the more marked will this condition be. If it is necessary to take this relation into account, as it may be, the cost accounting will involve keeping a record of material that has been issued to the process in question, and of the amount that has issued from it during the accounting period, in order that at the end of the period the quantity remaining in process may be determined. The theory of this method[1] is simple, tho the arithmetic may be somewhat confusing in complex cases.

It should be noted, however, that this refinement is necessary only in extreme cases. In process production, as under the production-order method, goods should, in general, be shipped as soon as possible after completion. It is not possible to hold all the goods manufactured during an accounting period till the end of that period, so as to be able to compute accurately the cost of production; therefore, this cost must generally be computed upon the basis of expe-

[1] A brief and clear discussion of this problem will be found in "The Science of Accounts," by H. Bentley, p. 237.

rience in manufacturing similar goods. It will be noted, also, that many expense items can be allocated only approximately; and, where more than one line of goods is in process, accurate allocation is as difficult under the process-production system as under the production-order method. No definite rules can be laid down for these more complex process methods; each problem must be studied independently, individual judgment entering largely into the solution of the problem involved in each set of conditions.

8. *Other difficulties of process-accounting.*—The discussion assumes that the processes considered are continuous, and that all the material of each kind passes thru the same series of machines. If the combination of machines and processes varies from day to day, all the difficulties discussed under the production-order method appear at once. If this takes place, even tho there may be some semblance to continuous production, it is better to pass the material thru in lots, assigning a production order to each lot. Even then, there will be forms of process production that will be troublesome to the cost finder.

In intermittent industries, for instance, there are processes which are continuous in character, and which use considerable expense material the cost of which is difficult to allocate. Processes where material is dipped in insulating fluid—japanning and baking processes, etc.—are instances of this kind. In processes like cement-making it is possible to weigh the material, and to use the weight as a measure of labor

and expense. But in processes like those others just mentioned, such a measure of labor and of expense material is difficult to obtain. Thus, in plating or dipping, the superficial area of the material treated is the proper criterion for measuring expense material, and this area is difficult to obtain. The expense material itself may be measured, but here again more than one kind of product may be treated at the same time, a condition which makes the allocation difficult if not impossible. Similar remarks apply to baking processes where several kinds of products may be baked simultaneously, and where the accurate allocation of direct labor and indirect expense may be impossible. No rules can be laid down for complex cases like these, but a knowledge of correct principles, combined with good judgment, will always indicate compromise methods that will give results, accurate enough, without too much complication.

REVIEW

How should the transportation expense in a factory be handled?

What are the salient features of continuous-process cost finding?

Why are continuous-process costs easier to determine than the costs of intermittent processes?

Is any advantage gained by passing material thru continuous processes in lots?

CHAPTER XIV

DISTRIBUTION OF ADMINISTRATIVE EXPENSE—RÉSUMÉ

1. *Distribution of administrative expense.*—Administrative expense and selling expense in most factories, and particularly in small factories, are treated as one item, under the name of general expense, and are usually distributed as a percentage on factory cost. In many such cases it is not possible to make a clear-cut division between these two classes of expense, but whenever possible they should be treated independently, if for no other reason than to fix responsibility. In large enterprises it is usually possible to segregate them, since the sales organization of a large works is usually an independent one; but even here there may be items of general superintendence that should be divided between the two branches of general expense.

It is difficult to distribute administrative expense over factory product in proportion to services rendered, by any method of allocation. Where the factory is very large and divided into departments, each with its own office force, an approach to intelligent allocation can be made, but the average factory is not so arranged. The usual method is, therefore, to dis-

tribute the administrative expense as a percentage on factory cost.

Thus, if the factory output for any month is \$50,-000 and the administrative expense for that period is \$10,000, the percentage by which the factory cost of each article must be increased in order to absorb the administrative expense will be $\frac{\$10,000}{\$50,000} = 20$ per cent. If, then, the shop cost of a given machine is \$200, its cost, including administrative expense, will be \$200 + \$40 = \$240. The factory cost plus the administrative cost is sometimes called the gross cost.

2. *Selling expense.*—Selling expense is even more difficult to distribute over the product in proportion to services rendered. In the first place, selling has no connection with manufacturing. The factory may be in the country and the sales office may be, and often is, in the city. There is no relation between the two branches, and hence there can be no relation between individual items of selling expense and factory orders. Occasionally, of course, a salesman may do work on securing an order for a particular machine and may be successful. On the other hand, he may fail to secure it, and an order for it may come in unsolicited from some other quarter. Much of the work of the salesman is "missionary," or advertising work, and it is difficult, often, to trace and identify the results of his efforts.

Where the enterprise is very large, and the sales force is divided into departments according to the

several lines of product, the cost of selling the several lines may be intelligently allocated against each line. But here, again, there is seldom any connection between the cost of selling an article in any given line and the cost of producing it, the latter being fixed by conditions that are entirely independent of the cost of selling. The best that can be done, therefore, is to distribute the selling cost as a percentage, just as in the case of the administrative expense.

The computation is simplified, of course, if both administrative and selling expenses are lumped together for distribution, and this procedure is customary in most plants. It should be noted, however, that there is no reason why the details of such expenses should not be carefully segregated so that the manager can see not only the separated totals of administrative and selling expense, but also the important details of these expenditures. Some suggested details of these expenditures are given in Section 7, Chapter VII, but evidently the extent to which such detail may be logically carried will depend on the size and the character of the enterprise. It is evident that the greater the proportion of the selling expense that can be definitely allocated to each product the more accurate will be the cost figures.

3. *Departmentization.*—The advantages of departmentization with reference to cost finding have been referred to several times in the preceding discussion; it may be helpful to note several other aspects of this feature of factory organization. From what has al-

ready been said, it will be evident that cost finding is closely connected with factory management; and yet, in times past, little or no attention has been paid to the problem of cost finding, either in arranging the plant or in organizing its personnel. It will appear, however, that this question should at least be kept in mind in perfecting both plant arrangement and organization.

If a manufacturer were to engage in producing two widely different commodities in two factories, placed side by side, he would naturally organize all "services" for one shop separately, distinct from similar services in the other. He would wish to keep his bills for power, heat and light separate for the two shops and would arrange his transmission machinery accordingly. The bookkeeping systems would be independent of each other and every cost factor would be strictly allocated to the factory to which it belonged. The manufacturer would expect to be able to keep the records of his two activities entirely separate.

On the other hand, a manufacturer might and often does, produce articles of widely different characteristics in the same factory, without any thought of arranging either his plant or his men with a view to separating, as far as possible, the manufacturing costs of the several items. Yet a careful consideration of the cost-finding problem will lead to radically different methods of distributing heat, light, power and similar services, and careful departmentization, with

the cost problem in mind, would often simplify this same problem.

The foregoing discussion will have made it clear that the problem of distributing factory expense in any department approaches simple division of such expense as the tools employed become more equal in size and value, as the wages paid approach uniformity, and as the work performed becomes more and more uniform in size and character. The problem of distributing the expense over a department containing twenty-five lathes of the same size and value, operating on exactly the same part, and operated by men of equal wage value and productive capacity, is extremely simple. Such a group can be considered as a large production center and it is comparatively easy to allocate the expenses to it in bulk, and simple division of this bulk is about all that is necessary, if any at all is necessary. On the other hand, the problem has been shown to become increasingly complex as the component factors named vary increasingly in size, character and value.

4. *Departmentization according to finished product.*—Now there are two distinct methods, or principles, for grouping machines and processes. These affect very greatly not only the physical arrangement of the plant, but also its personal administration, and the ease and accuracy with which expense may be distributed. The first method is to group the machines or processes on the basis of the *character of the fin-*

ished product. Thus, in a large machine-tool works organized in this manner, one department would be equipped with a complete set of machines and tools for building lathes; another would be similarly fitted out to build milling machines; and another would have all the necessary appliances to build drill presses, and so on, each department being equipped entirely independently of the others, and being self-sufficient for the purpose for which it was organized.

This method is a natural outgrowth of conditions in a small shop where the number of tools of any one kind was limited. As new lines of production were added their processes grew up around the personality of some strong executive, or manufacturing superintendent, who often did not want to assume the responsibility of production and delivery unless he had full control of the major part of the productive machinery required. Many executives of strong personality were impatient of the restraint imposed by the necessity of close cooperation between departments. The result of their influence was excessive duplication of tools and processes, and the prevention of the use of more modern forms of administrative organization. This failure to recognize the importance of changing the form of organization as the enterprise grows in size, has doubtless been responsible for the failure of many once prosperous concerns.

5. *Departmentization according to processes.*—Modern organization, however, moves along different lines. It tends to substitute staff organization for

individual effort, to replace the versatile individual with coordinated specialization, and to arrange machines by processes rather than by products. Under this second method, therefore, all machines of approximate size and character are grouped together. Thus, in the example taken above, all turning would be done in one department, all milling in another, all planing in another, and all assembling in another. In each of these departments, in turn, all machines and processes of similar kind and size would be grouped together. Thus all small lathes engaged in manufacture would be in one group, all large lathes in another, and so on. Even in the assembling of the completed product, while all assembly might be in one department, each class of product would be assembled by itself. In other words, by this method all similar production centers would, as far as possible, be grouped so as to form a large production center, the component parts of which would not vary greatly.

It is evident that this modern method is by far the most economical, and that fewer tools of any given kind will be needed, since the possibility of keeping all machines in operation is much greater when all tools of one kind, and the work which can be done upon them, are collected in one place. The indirect expense for superintendence will be less, and the volume of the product will be greater, since specialization can be made more effective.

Both principles, organization on the basis of products, and that on the basis of processes, should be

given careful attention in arranging the plant, since they directly affect accuracy of cost work. In a very large works, for instance, the entire plant may be arranged by products, certain definite buildings being devoted to definite lines of work, so that the total costs of each line may be easily segregated. The tools and processes used in each line of work may, however, be arranged to best advantage by the other method; that is, according to the processes performed. Careful consideration of the arrangement may make it possible to use a simple cost-finding system, whereas lack of such consideration may make the problem so complex that it cannot be solved even by the most elaborate method. It should, of course, be noted that strict adherence to either form of organization is neither necessary nor indeed always possible. Many departments that are equipped primarily to perform a given process often require a few tools of entirely different kinds, simply to save time and transportation. While space does not permit further discussion of this problem, it is one which requires the careful attention of the manager who is interested in costs.

6. *Résumé of methods of distributing expense.*—The consideration of the several methods of distributing expense and the discussion in Chapters VII and VIII regarding the character of its several items, will have made it clear that exact allocation of factory burden is not, in general, possible. It is true that in very simple cases, such as are found in the continuous industries, the distribution may be as accurate as is

desired, but the general case of intermittent manufacturing does not admit of an exact solution. Even tho clerical machinery be installed which, theoretically, will give accurate results, the expense items themselves are so variable as to make exact distribution difficult even in simple cases, and impossible where the conditions are complex. This fact is made clear when it is considered that the exact expense to be distributed is itself not always accurately known; distribution must be based on records of the past week, month, or year, as the case may be. In most cases the record of the previous month is used as a basis, but it may be that in some cases it will be better to base the distribution on the average of a number of preceding months. In all cases, however, heavy periodic expense investments should be spread out so as to equalize the costs. The fact that there are so many methods and theories of distributing expense is perhaps due, to some extent, to the fact that there is no absolutely accurate method. The need of some theory on which to build a system of expense distribution is self-evident, but it is equally plain that the theory adopted should be capable of practical application. The method that will be satisfactory in one case may not do at all in another. There are, however, two fundamental principles that should be remembered no matter what system of distribution is being considered.

First, the cost records obtained should state, so far as possible, the facts of the case; they should be records of events that have happened and of nothing

else. A clear-cut distinction should be made between costs, as such, and their interpretation and use, which is another matter. Systems of cost based on estimates are in common use. Obviously, such methods cannot be considered seriously, either for accuracy or as a guide for future action. But, altho the primary object of a cost system is to state facts, due consideration should be given to the use to which these facts are to be put. In general, the two main uses of costs are, first, to show how money has been spent and, second, to indicate how such expenditures may be controlled. In organizing a cost-finding system, therefore, the form in which cost returns are recorded should be carefully considered so that classification and analysis may be rendered easy and simple. A later chapter will treat this matter more fully.

Second, the system adopted should be as simple as it can be, and still be consistent with the problem in hand. The average manager is a very busy person, usually demanding methods that are simple and easily followed and, ordinarily, being suspicious of methods that he cannot understand, or results the derivation of which he cannot easily see. Furthermore, the system should be stable and not subject to constant readjustment because of slight changes in operating conditions, since readjustment usually destroys the possibility of comparison with costs already existing.

For these and many similar reasons the cost system adopted is usually a compromise which takes into account the surrounding conditions. Thus, it would be

a useless expense to instal an elaborate machine rate and supplementary rate in a continuous-process industry where a single product is being produced and where a simple method of percentage on material would be accurate enough. Again, in an industry making a few lines of goods of similar characteristics, where the parts do not vary much in size, and where the machines are all small and inexpensive, a method based upon percentage on wages or upon hourly burden might give results sufficiently close. In more complex cases, as in intermittent manufacturing, where many commodities of varying size and character are made, it has been shown that these simpler methods do not give intelligent results. If the competition is keen the wise manager will go as far as he can in the direction of the machine rate and the supplementary rate. Even in cases of this kind conditions may be such as to permit the use of simpler methods, particularly if careful departmentization can be effected. The general influence of departmentization on costs should not be lost sight of, since by this means all cost-finding methods are strengthened, as has been noted in discussing the several methods of distribution. A later section will discuss this important factor somewhat more fully.

Above all, the manager himself should have a clear-cut view of just what he wishes to do. In general, the practical manager must have the help of an expert organizer to assist him in installing a new system, but he himself should be able to limit intelligently the

extent to which the system is carried. It is one thing to lay down general principles, and another to know how far they can be economically carried. One of the most common errors of cost-finding experts who are lacking in practical experience, is to oversystematize in installing new cost-finding systems, with the result that much useless information is gathered and eventually much of the elaborate system is discarded. The cost-finding expert should be master of the principles of his business; the practical manager should supply the limitations of the system. And finally, it is of supreme importance that *some* system, be it ever so simple, should be in service. A factory without a cost-finding system is like a ship without a rudder, and in these days of strenuous competition it is sure to run on the rocks of failure.

REVIEW

How would you distribute administrative expense?

Upon what basis is it advisable to distribute selling expense?

If part of the selling expense is incurred in securing orders for the next season's delivery, would you consider it proper to carry forward such portion as an asset to be charged against the next season's sales?

What do you understand by departmentization: (a) according to finished product? (b) according to processes? Which of these methods is more in accordance with modern ideas of organization?

What are the fundamental principles to be taken into consideration in the planning of any system of expense distribution? What are the difficulties to be anticipated?

CHAPTER XV

ASSEMBLING AND RECORDING COSTS

1. *Uses of costs.*—It will be evident that the manner in which costs are recorded and the detail with which the recording is carried out will vary greatly with the enterprise, and with the point of view of the manager. In some simple continuous processes lump sums only may be required, while in intermittent production involving many kinds and many sizes of parts, the detail in which costs are collected and recorded may be very great. The detail of cost accounting will also vary greatly with the purposes for which it is desired to use the collected cost data. These purposes may be several, but in general they may be summed up under these heads:

(a) To show the actual cost of operations or performances.

(b) To serve as a basis for predicting future performances.

(c) To form the basis of managerial and other reports.

The first purpose constitutes, of course, the fundamental reason for keeping costs. In so far as total profits are concerned, there is no necessity, as will be shown, for a cost-keeping system. But it is essential

in most industrial enterprises to know, as closely as possible, the cost of producing each individual article, sometimes even of each part, if for no other reason than to know which lines are paying and which are not. It should be fully realized that factory costs are not always serviceable in fixing selling prices. In many instances the selling price must be fixed by the prevailing market price, and this may have little relation to the cost of manufacture. Such circumstances are especially likely to prevail in lines of work where cost-finding methods are, in general, crude and poorly understood. Yet this is all the greater reason why, in such cases, costs should be known as accurately as possible. A knowledge of the details of the cost of producing any article is a good start toward reducing the cost. A knowledge of the actual facts concerning the cost of production of each article, as far as it is economical to obtain them, would seem to be a common-sense requirement for a continuation of any enterprise. There is no doubt that it is a lack of this fundamental knowledge which carries many enterprises "to the wall." The detail methods of recording cost data will be discussed in this chapter.

2. *Cost data for predicting performance.*—As already noted in Section 3, Chapter III, a cost-finding system that is used only for recording costs has fulfilled only a part of its true purpose. Too many managers think of costs simply as records of performance, whose usefulness is ended once the goods are billed. Now the most significant movement in modern manu-

facturing is the tendency to predict all manufacturing performances. The engineering and designing departments long ago began the prediction of the constructive features of manufactured products. The form and dimensions of all manner of articles and even of the tools for producing them are predicted, as well as the practical and theoretical performance of the completed product. Careful managers have for many years endeavored to foretell the times and costs of productive operations with the same degree of certainty that has been attained by the engineer and the designer. One of the cardinal principles of so-called "scientific management" is the securing of advance knowledge of the time and cost of each operation in detail, without leaving anything to chance or judgment. And just as collected scientific knowledge forms the background of production in general engineering, so collected cost data, including the two important factors of time and wages, form the basis of all predictions of productive performance. The relation of time study and motion study to cost prediction is the same as the relation of engineering research to engineering design. Any system of recording costs, to be most effective, must be arranged with this feature of management in view. A more extended discussion of this important phase of cost finding is given in Chapter XVII.

3. *Value of expenditure reports.*—In addition to the two functions of cost records discussed above, reports, should also show the distribution of expendi-

tures. The total expenditures, while showing the manager the probability of gain or loss, do not tell him much regarding the ways in which money has been spent, or indicate to him where he must insist upon retrenchment and improvement. He cannot find this information by a personal inspection of the details of the cost records, except as those records apply to specific parts. If, however, the cost data are carefully classified and gathered up into reports, a very clear idea of the most important tendencies in the business can be secured by the manager. Classification and summarizing of cost data according to the character of the expenditures is hence an important feature of cost recording, and it must be kept in mind in the organization of the clerical machinery of the department. This feature of management will be more fully discussed in Chapter XVI.

4. *Sources of cost data.*—The detail necessary in recording costs of production will vary with the relative amount of consideration given to the three general uses of cost data which have just been discussed, and also with the amount of detail involved in the job concerned and the character of the processes used in doing the work. Obviously, no one system is applicable to all cases, but there are a few general principles in common use which may be helpful. Referring to the last item, the character of the processes used, one can clearly see that the methods used in summarizing costs for a continuous-process factory, or for one using processes in such a manner that it is difficult

to tell where one job stops and another begins, will be somewhat different from the production-order method, by which each job is kept distinct from all others. The discussion will, for the present, be confined to the production-order method; the process method will be considered later.

It will be remembered that in the production-order method all time expended is recorded originally on some form of work card (Figures 9, 10 and 11, pages 85, 87), which identifies the work performed with the shop-order number, the part or drawing number, the time expended, and the workman who does the work. All material used will be reported from the storeroom by means of the requisition on which the material has been issued. Sundry expenditures which are neither labor nor material but which are chargeable against specific jobs, will appear on properly approved vouchers. The indirect charges will be reported just as direct labor and material are reported, so as to be charged against the proper standing-expense order numbers, to allow of their total amount for any given period being ascertained.

5. *Cost ledgers.*—Now if the work is of such a character that each shop order involves only a few charges for material and labor, it is obvious that such charges, with the correct expense charge belonging with them, could be carried directly to the general-ledger account of the order concerned, and with any other charges properly relating thereto the entire transaction could be recorded in one small ledger ac-

count. On the other hand, if the job involves many operations and its construction is to extend over a considerable period of time, such procedure would make the general ledger too bulky and would tend to obscure its true object as a summary of the business. For this reason costs of a complex character are usually collected by some form of cost ledger, the function of which is to record permanently the details of items entering into the cost of production. Summaries only of the cost ledger without details are carried to the corresponding accounts in the general ledger.

Cost ledgers, like all other subsidiary ledgers, such as the stores ledgers and stock ledgers, are most conveniently made up in the form of a card system. The forms of ruling for such cards must, of course, be suited to the requirements of the business. If the number of entries for each job is not too great, a single card may suffice to carry the record of all the details of its production. A cost-finding sheet of this character is shown in Figure 16, opposite. It will be noted that provision is made for recording the cost in considerable detail under the three principal factors, material, labor and expense. The several operations performed upon the piece are noted, with the workman's number and his rate. The total cost also is usually noted upon the card by adding the general expense to the total factory cost as recorded.

It may be more instructive, however, to describe a typical method of recording costs where the details

COST SHEET

NAME OF ARTICLE ____________
DATE FINISHED ____________
NUMBER MADE ____________
UNIT FACTORY COST ____________

SHEET NO. ____________
CATAL. NO. ____________
DRAW. NO. ____________
PROD.-ORDER NO. ____________

DATE	MATERIAL					LABOR					INDIRECT	
	DESCRIPTION	REQ. NO.	QUANTITY	RATE	AMOUNT	OPERATION	CHECK NO.	HOURS	RATE	AMOUNT	%	AMOUNT
TOTALS												

FIGURE 16

are beyond the capacity of a single card. It will be understood that the procedure described is a typical one only, and simply suggestive of the general methods in common use. The discussion will be confined for the present to the problem of finding total costs, which was stated as the first of the uses for which costs are kept.

6. *Labor and material cards.*—When a production order is placed in the shop an account is opened in the cost ledger by placing in its files the necessary cards properly filled out. These will consist generally of a labor-cost card and a material-summary card. The work cards (Figures 9, 10 and 11, pages 85, 87) are collected daily and, after being approved by the proper foreman, are forwarded to the cost department. Here they are first sorted according to workmen's numbers, that is, all the cards sent in by any one workman are grouped together. It will be noted that, in best practice, each workman will send in, daily, a separate work card recording the time he has worked on each and every job, whether he has finished the job or not. The difficulty of separating different labor items placed upon the same work card will be apparent. The wages represented by each card are now computed and noted thereon. This may be based upon day-pay, piecework or premium-plan methods, but in every case the wage so recorded is the labor cost chargeable against the job, so far as that particular work card is concerned. If the expense is distributed by machine rate, or if different percentage rates are

used for different departments of the factory, the expense belonging to each work card should also be computed at this time and noted upon the card. If a fixed percentage is used for all work alike, it is generally more convenient to defer the computation of the burden until later.

The total time recorded by each man can then be checked against the time-clock or the checkboard record to insure that all elapsed time recorded by these records is accounted for. The daily pay-roll may now be made out. If all men are on day pay an independent pay-roll may be made out, based upon the clock or the checkboard record; this must check against the costs as shown by the work cards. If, however, piece rates or a bonus system be in use, the pay-roll should be based upon the work cards, tho, even then, the elapsed time must check against the clock record.

7. *Labor-cost sheet.*—The work cards are then sorted by production orders, that is, all cards bearing the same production-order number are brought together. The items refering to each production order are then posted on a labor-cost sheet, as shown in Figure 17 (page 238), a separate sheet being made out for each production order so that the total labor cost of the order concerned can be summarized at any time. In cases where the labor charges are few, they could, of course, be posted directly to a cost-summary card, such as is illustrated in Figure 16 (page 235). The detail in which the labor cost may be recorded on the

LABOR-COST SHEET

NAME OF ARTICLE____________ SHEET NO.____________

NUMBER MADE____________ PROD. ORDER NO.____________

DATE	CHECK NO.	HOURS	RATE	LABOR COST									TOTAL
				ASSEMBLE	BORE	DISMANTLE	DRILL	GRIND	HARDEN	MILL	PAINT	TURN	
TOTALS													

Figure 17

labor-cost card must, of course, vary with conditions. It may be a simple running memorandum, a summary of which will give only the total labor cost of all operations, or it may be arranged so as to give the total labor cost by operations, as illustrated in Figure 17 (page 238), where similar operations may be totaled. Either the amount of each work card may be recorded, or the cards may be recorded in groups, as conditions dictate. In so far as securing total labor costs is concerned, the work cards are no longer necessary after they are posted on the labor sheet. Their further use in securing statistical costs will be discussed later.

8. *Material-cost sheet.*—The material requisitions, after being properly evaluated and posted to the material accounts either by the storekeeper or in the cost department may, if their number is small, be filed with the labor-cost sheet. If, however, there are many material entries they may be posted on a material-cost sheet in the same way that labor charges are carried on the labor-cost sheet. For the ascertainment of total charges the material requisitions have then fulfilled their service, but like the work cards they are still useful for statistical purposes.

The costs of indirect labor and material are gathered in the same manner as in the case of the direct costs—the detail costs, as they come in on work cards, and the material requisitions being carried to the proper expense accounts. The total of these expense accounts must be compared periodically with those of

preceding periods, to insure that the factors used in their distribution are accurate.

9. *Cost-summary sheet.*—From the labor-cost sheet and the material-cost sheet the total prime cost to date may be summarized at any time. When the job in question is finished, the summaries of both of these sheets are carried to a cost-summary sheet. If only one article is involved and all labor and material items are carried to a cost-ledger card, as shown in Figure 16 (page 235), the summary may be made directly upon it. To the prime cost, so summarized, is added the expense, if it is distributed by a percentage method; or the proper proportion of the supplementary expense is added if the machine-rate method of distribution is in use. If there are any sundry charges that are chargeable directly to the production order as shop expense, these are also added; in this way the factory cost is completed. To the factory cost is added the proper percentage for general expense and selling expense, and thus the total cost of the article is obtained.

10. *Grand cost summary.*—If any particular job consists of many parts, and production orders have been issued for each part, so as to segregate its cost, a grand summary of all cost-summary sheets for the entire job must be made, as shown in Figure 18, opposite, which illustrates clearly the summarizing of the costs for a direct-acting steam pump. The figures given are hypothetical and taken somewhat at random. The need of such methods will be made more

COST-SUMMARY SHEET

NAME 16×9×12 Dup Pump
NUMBER MADE 1

SHEET NO. 642
PRODUCTION NO. 2346

NUMBER	NAME OF PART	MATERIAL		LABOR		PRIME COST		EXPENSE		COST	
2	Steam cylinders	35	45	50	20	85	65	40	16	125	81
2	Water cylinders	50	20	60	10	110	30	48	08	158	38
1	Frame	15	60	20	05	35	65	16	04	51	69
1	Steam piston	5	06	15	16	20	22	12	12	32	34
1	Water piston	7	08	14	64	21	72	11	71	33	43
1	Piston-rod	3	04	2	60	5	64	2	08	7	72
1 set	Valve gear	7	24	24	06	31	30	19	24	50	54
1	Air chamber	6	80	2	46	9	26	1	96	11	22
	Assembling and testing			64	20	64	20	51	36	115	56
	Miscellaneous			6	24	6	24	4	99	11	23
	Factory cost									597	92
	General expense 15%									89	69
	Selling expense 5%									29	90
	Total Cost									717	51

FIGURE 18

apparent by a consideration, for example, of the costs of a large multiple-cylinder marine engine, where it is desired to obtain the individual costs of the several parts, or group of parts, which make up the engine. Or, again, if it is desired to obtain not only such individual costs but also the summarized costs of the propelling machinery, such summaries are a necessity. In the example shown, Figure 18, the factory expense is computed separately, as would be necessary if different percentages were used in different departments. The general and selling expense is also computed and added, and in this way the total cost is obtained.

11. *Comparative records.*—It will be evident that the above methods are sufficient for the purpose of recording total costs. If, however, it is desired to use these recorded costs as a means of fixing piece rates, or estimating on contracts, it is very often desirable to express them comparatively, since a single set of costs is not likely to be reliable as a guide to future work. If costs are recorded by production-order numbers, as explained in the foregoing discussion, only the totals of the several items are quickly available.

In the case of the pump, illustrated in Figure 18, the summary will have back of it a number of subsidiary summaries, each giving the total for one of the components of Figure 18. If these subsidiary summaries are filed under the controlling production-order number, it is obvious that more or less difficulty will be experienced in finding the comparative cost of

a given piece as manufactured for different pumps of the same size and kind.

12. *Costs by classes.*—If, on the other hand, the cost of detail parts is recorded by classes and not by production-order numbers, this difficulty is obviated. This method is illustrated in Figure 19 (page 244) where the details of the manufacture of several lots of turret-lock rings for turret-lathes are thus recorded. The record given in Figure 19 is very complete, the work being recorded by classes and also by production orders. The M, A and H, under each class of operation, indicate whether the work has been done by a mechanic, apprentice or helper. The number of minutes expended on each operation for the lot is recorded and directly underneath is the cost per piece. On the right the totals of these items are summarized, together with the total cost per piece in each lot. Records of this kind are very instructive in setting piece rates or comparing methods of production.

13. *Detail of costs.*—In the case of the construction of a single machine or of a small number of machines, where a repetition of the order is not probable, it is sufficient to record the cost by production-order number, filing the detail and summarized costs which are obtained, under a few order numbers. But in manufacturing a standard product, which is in more or less continuous production, the method of filing by classes is much more useful. Many so-called "border-line" cases arise in which judgment must be relied upon in choosing the most practical method. Obviously, many

MATERIAL T.S
WEIGHT 10#
PRICE .05
NO. ON EACH MACHINE 1

COMPARATIVE-COST SHEET

ARTICLE Turret Lock Ring

SHEET NO. 2368
DRAW NO. 4679A
CAT. NO. 02468
DATE 4-11-2—

Lot No.	Prod-Order No.	No. Made	No. of Min. for Each Operation and Cost per Piece in Cents																																	Material	Expense	Total Cost per Piece
			Planing			Turning			Drilling			Milling			Boring			Shaper Work			Grinding			Scraping			Vise Work			Total Time and Cost per Piece								
																														M		A		H				
			M	A	H	M	A	H	M	A	H	M	A	H	M	A	H	M	A	H	M	A	H	M	A	H	M	A	H	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.			
						54					39		79				70				70	186								2	4	4	25	1	47		100%	
11	386	20				24					13		8				22				37	23									61		31		35	.50	1.27	3.04
						107					32		25				63				63	68								2	50	1	33	1	35			
12	418	22				54					10		6				21				34	7									58		13		31	.50	1.32	3.14
							62				31		49				50				62									1	2	1	51	1	21			
13	438	25					8				10		5				18				33										33		13		28	.50	.74	1.98
						38					41		53				44				79									1	57		53	1	25			
14	450	25				18					12		7				16				23										41		7		28	.50	.76	2.02

FIGURE 19

variations may be made in these methods, and it should be remembered that the usefulness of the final cost record depends largely upon the intelligence with which the production orders are issued. In one case it may be sufficient to group all costs under a single order number and summary; in another it may be necessary to divide the job under a number of production orders, and to carry the summarized cost of each group to a grand summary under the main order number; or, again, it may be necessary to record all costs by classes and make up the total cost of a given product from class costs. In still more complex cases the main parts of a machine may be made on a special production order, while, to complete it, many auxiliary parts may be used that have been manufactured on class-order numbers. In the last method, the drawing list, Figure 5 (page 55) is an essential feature of the production process.

14. *Indexing cost summaries.*—It is clear that in a busy factory turning out many jobs monthly the cost-summary cards will increase rapidly. They should therefore be filed in some systematic manner, and if necessary should be indexed in some way so as to make reference to them quick and accurate. In many cases an alphabetical index by customers' names may be sufficient; but in most cases filing and indexing by classes is necessary. All generator costs may be filed together, all induction-motor costs may be filed together, and so on. Thus, this method contemplates the working out of a complete system of filing and

indexing by classes. For instance, following this scheme of classification all cylinder-head costs are filed together, all connecting-rod costs are filed together, and so on. It is clear that a good index makes the cost records very much more effective; in fact, in large systems it is indispensable.

15. *Relation between general accounts and cost accounts.*—From the foregoing discussion the relation between the general books and the cost accounts will be clear. The general accounts, as a rule, concern the operations of an enterprise as a whole. The entries in these books cover the exchange of values between the organization and other organizations or individuals. They do not take cognizance, in detail, of inventories, changes in plant valuation, or manufacturing expenses. The cost accounts, on the other hand, are concerned with the movements of values, in detail, within the organization. They are particularly concerned with inventories, depreciation, the distribution of manufacturing expense, and similar items.

Cost accounts should be regarded as detailed statements, or amplifications, of the condensed statements shown in the general accounts. They should give in detail the causes which produce the totals, and should enable the manager to reason intelligently regarding these totals.

It should be carefully noted that, so far as finding the total profit or loss of any enterprise is concerned, cost accounts are not generally necessary. Thus, re-

ferring to Figure 3 (page 26), it can be seen that all the items necessary to show profit or loss can be found from the general accounts, except the items of inventory. As before noted, these inventory values may be found by visual appraisal. In many enterprises this practice still prevails, tho, as has been stated, it is to be recommended only as a check on the more advanced inventory methods that have been discussed.

It is customary in many enterprises to show the results of the manufacturing and trading parts of the business by what are called "manufacturing" and "trading" accounts. On the debit side of the manufacturing account is placed the inventory value of the material in stores and in process at the beginning of the period under consideration, while the value of the same items at the end of the period is placed on the credit side. The difference is the gain or loss in these values. The value of the purchases and the wages paid during this period, with all legitimate manufacturing expenses, are also placed on the debit side. The balance of the account, representing cost of manufacture, is charged to the trading account, on the credit side of which are placed the receipts from sales. The selling and administrative expenses are also charged to the trading account. The difference between the two sides of the account shows whether a gain or a loss has resulted during the period under discussion.[1]

[1] See discussion of this subject in the Modern Business Text on "Accounting Principles."

To ascertain the total profits, therefore, it is not necessary to know the manufacturing cost of individual pieces of product; only the total cost and total sales are needed, provided an inventory is compiled at the beginning or the end of each period for which a financial statement is made. There are many concerns in this country that still operate on this plan of selling at market prices, regardless of manufacturing cost; they rely on a periodic inventory to find out whether a loss or gain has occurred. Such an inventory cannot be conveniently made, in most cases, more frequently than semi-annually, and the danger of such a method is self-evident. On the other hand, some accountants and auditors have little faith in cost-accounting methods; they prefer to deal with values which are definite, as is the case with direct expenditures for material and wages, and inventory values based on visual examination of the assets. They prefer this method of ascertaining the total cost of the manufactured product.

16. *Cost accounts should agree with general accounts.*—A cost system may, therefore, be operated with little relation to the general accounts. It might, indeed, be useful to the shop manager as a guide in operating the factory, and might serve also to fix selling prices, without being closely connected with the general books. It should not be forgotten, however, that if the cost system is at all accurate, the sum of the detail values which it shows will agree closely with

the corresponding totals as found in the general accounts. It should be noted, also, that the general accounts are the only means available for checking the accuracy of the cost accounts. For this reason the cost accounts should be closely connected with, and merged into, the general accounts. In very simple cases, the general books may include all the detailed costs that are collected.

In a manufacturing business, for instance, the following accounts might appear among the general accounts:

Machinery and equipment
Reserve for depreciation
Patterns and drawings
Small tools
Raw materials
Manufactured parts
Factory supplies
Manufacturing expenses
Goods in process
Finished products.

Clearly, these accounts must be fed from the cost accounts, and it is possible to create such general accounts as will serve to collect the totals of the cost accounts. If the cost accounting be correct, the totals thus obtained will check closely with the totals that are found directly from the pay-roll, the cost of purchases, and other accurate sources of value. Thus, the sum

of the wages which are charged in the cost accounts against productive orders, and which appear in detail in the several job accounts, should agree with the total direct pay-roll as reported by the paymaster. The total manufacturing expense charged in detail thru the cost accounts should agree closely with the totals of such expenses as shown by the purchases and the indirect pay-roll. The material charges, however, cannot be made to check so exactly, since the element of waste, and similar losses, cannot be accurately evaluated; but even these totals should not differ greatly. If they do the error should be found. In general, of course, the error is more likely to be found in the cost accounts than in the general accounts.

The degree to which the general accounts and the cost accounts may thus interlock will, necessarily, vary with conditions and with the opinions of those concerned. It seems that, in this country at least, the tendency is toward a closer relationship between the two sets of accounts. This is logical, since, as has been explained, the cost accounts are really an amplification of the general statements and should be accurate enough to check, at least fairly well, with the more accurate general accounts.

REVIEW

How would you rule a form of cost-summary sheet; a labor-cost sheet; a comparative-cost sheet?

What are the sources of cost data and the general methods of securing them?

Could you outline in the form of instructions, the several steps in assembling cost data?

How would you index cost summaries so as to provide for quick and accurate reference?

Do you clearly understand the relation that the different forms mentioned in the text bear to one another?

Discuss the relation which should exist between the cost accounts and the general accounts.

CHAPTER XVI

ANALYSIS AND REDUCTION OF COSTS

1. *Use of cost data.*—It was noted in Section 3 of Chapter III that the first use of a cost system was to record the results of operations and the discussion up to this point has had to do with this phase of cost finding. Figures 16, 17, 18 and 19 show clearly the summarized costs of operations, and normally such records should serve as a basis for fixing selling prices. It is often objected, however, that the selling prices cannot be fixed by cost data, but are fixed by the market, which again is controlled by competition. This is undoubtedly true, and it is true, furthermore, that market prices may be so low as to be ruinous to all but the cleverest manufacturer. There is no doubt but that many failures are due to lack of accurate knowledge of costs on the part of the individual and on the part of the industry as a whole. And herein lies one of the greatest justifications and one of the greatest uses of a cost system.

If the market price does not permit a margin of profit over the recorded costs of production the next logical step is to bring the costs of production down to a point where such profit is obtainable, and there is no [illegible]tive method of doing this without the aid of a [illegible]ducted cost-finding system. For this pur-

pose the information shown on Figures 16, 17, 18 and 19 is not sufficient, and a study of such summarized records does not throw sufficient light on the problem. More detailed information must be at hand.

2. *Organizing for cost reduction.*—Nor is cost reduction a problem that can be satisfactorily undertaken by any individual. The cost of any given product is the work of many hands and many minds, and problems of cost reduction are best approached by calling together the leaders in the several activities thru which cost accumulates. As explained in Chapter V in the volume on "Plant Management" of the Modern Business Text, the committee system is a powerful method of attacking all such problems. A committee consisting of the engineer and the designer of a product, the tool maker, the cost clerk, and a representative of the manufacturing organization can often work wonders in cost reduction. It should be remembered that manufacturing is a difficult matter, and the interchange of ideas around a committee table can be made just as effective in this work as it is in other lines of human activity. The designer can often obtain valuable hints from the shop foreman and the toolmaker, while the toolmaker may obtain a clearer idea of the financial problems involved from a discussion with the cost clerk and the factory superintendent.

3. *Relation to new ideas of cost control.*—It should be noted, furthermore, that the methods to be discussed apply to anv form of management. Chapters

IX and X of the volume on "Plant Management" deal at some length with the modern methods of predicting labor costs, using time study and motion study as means of so doing, and later chapters of this book deal with the general problems of cost predetermination. These modern methods in no way supersede the general methods described in this chapter, but they may be of great assistance in carrying out these general methods which were practiced before the advent of scientific management, so called. There are many industries, furthermore, where these more advanced methods of labor control are not feasible or necessary, but the problem of cost reduction is ever present in most enterprises.

4. *Cost analysis.*—It has been shown in the preceding chapters that cost is made up of material cost, labor cost, and expense. Of these three, material cost and labor cost can be identified with specific pieces of work, but expense is a general cost that cannot be allocated to operations as it is incurred but must be distributed on some other basis. Cost analysis for the purpose of reducing the cost of any particular piece of work must proceed along these lines. The general reports discussed in Chapter XVII of the volume on "Plant Management" of the Modern Business Text, while useful as will be seen in reducing expense, are not in general sufficiently detailed for use in individual cases; nor are the cost summaries shown in Figures 16, 17, 18 and 19 sufficient in general for the work under discussion.

5. *Special cost reports.*—For this purpose a special cost report, such as is referred to briefly in Chapter XVII of the volume on "Plant Management," is most desirable. Figure 20 shows such a special report taken from actual practice and which was used as a basis of studying the labor and material costs of certain electrical switches with a view to reducing the cost of production. The monetary values shown are in dollars and decimals of a dollar, and it will be noted that these values often had to be carried out into the fourth or fifth decimal place, so small are the values involved; but it should be remembered that these parts were to be produced in large quantities and such refinement was not only justifiable but necessary. With this report, with the actual parts of the switch itself and with all the special tools concerned, before them, a committee consisting of the switchboard engineer, the toolmaker, the chief cost clerk and the manufacturing superintendent attacked the problem of cost reduction with marked success. This investigation involved the consideration of the design of the switches as to manufacturing possibilities, a careful study of all tools and processes on hand and the development of new tools and methods. Careful consideration was given to the question of waste in fabrication, and many trial performances were made with a view of finding the piece rates that should be set for operations.

Such special reports are most useful, of course, in cases such as the one just cited, where production in large quantities was projected. If money has been

500 AMP. D.P. ST. SWITCHES TYPE L, FORM M. ASSEMBLY DRAWING M 1756

SERIAL NO.	NAME OF PART	DWG. NO.	PART NO.	MATERIAL	NO. PIECES	MATERIAL COST ONE PC.	TOTAL MATERIAL COST	LABOR COST ONE PIECE	TOTAL LABOR COST
1	BLADE	174,367	5	COPPER	2	.25176	.50352	.0076	.0152
2	" END	174,379	5	"	2	.0856	.1712	.0128	.0256
3	" STOP	174,390	4	B. FIBRE	2	.00372	.00744	.0025	.005
4	CROSS BAR	174,385	5	" "	1	.10	.10	.0148	.0148
5	FRONT CLIP RIGHT	174,369	3	COPPER	2	.06218	.12436	.0027	.0054
6	" " LEFT	174,374	5	"	2	.06218	.12436	.0027	.0054
7	HINGE CLIP	174,431	6	"	4	.05713	.22852	.0035	.014
8	HINGE BOLT	BOUGHT		BRASS	2	.01947	.03894	.0015	.003
9	HINGE BOLT NUT	BOUGHT		"	2	.00325	.0065	.0012	.0024
10	HANDLE NUT	014,097	A	STEEL	1	.0425	.0425	.0125	.0125
11	SPRING WASHER	014,095	1,383	PH. BRONZE	4	.01932	.07728	.0003	.0012
12	TERMINAL	BOUGHT		COPPER	4	.1224	.4896		
13	14 - 24 X 7/8" SCREWS	"		STEEL	4	.00125	.005		
14	PIN .181 X 3/4"	"		COPPER	4	.0011	.0044	.0004	.0016
15	" .128 X 1 3/8"	"		"	8	.00103	.00824	.00025	.002
16	" .128 X 1/2"	"		"	2	.00041	.00082	.0002	.0004
17	HANDLE	138,102	4	WOOD	1	.04712	.04712	.01	.01
18	CLIP BLOCK	174,392	3	COPPER	4	.0983	.3932	.0117	.0468
19	FUSE BLOCK	174,388	5	"	2	.08378	.16756	.0079	.0158
20	NUT FOR #21	BOUGHT		BRASS	8	.0186	.1488	.0015	.012
21	3/8-16 X 1 3/4" R-H. SCREW	"		STEEL	8	.0051	.0408		
22	3/8-16 X 1" " "	"		"	4	.0025	.01		
23	WASHER FOR 21 AND 22	"		STEEL	12	.0005	.006		
24	" " 25	"		BRASS	4	.00242	.00968	.0006	.0024
25	BASE	174,414	4	SLATE	1	.21	.21	.109	.109
						TOTAL	2.96584	TOTAL	.3045

OTHER LABOR COSTS:
- ASSEMBLYING .256
- STAMPING .012
- DIPPING .02
- BUFFING .40

FIG. 20 SPECIAL REPORT ON LABOR AND MATERIAL COST

FIGURE 20

lost in the construction of a single piece of work where repeat orders are not expected, reports of this kind may also be valuable because, if you know the sources of loss on one job, you can estimate costs better on others of a similar character and thus prevent similar losses on future production. Aside from the value of such a report in furnishing a basis of discussion and in showing the most promising opportunities for cost reduction, in its revised form when discussion is complete it acts as a standard which must be met to secure the results desired.

6. *Reduction of material cost.*—Cost reduction by saving material involves the consideration of quantity, quality and waste. If the designing is well done there is comparatively little chance of reducing the quantity of material used. This is particularly true in products where strength and rigidity are important factors; in such things as shoes, where a definite amount of material must be used for a given model, or in such products as the electrical switch illustrated in Figure 20, where both quality and quantity are fixed by engineering considerations and underwriters' rules. Nevertheless, there are many instances where a careful consideration of the material involved will result in considerable saving thru reduction in the amount of material or the substitution of other materials that are equally serviceable and less costly.

The subject of waste is often an important factor, especially where many parts are to be made by punching or otherwise cutting them from sheets or bars. A

small saving per piece on copper stock or leather goods may amount to a large total, and the methods to be pursued in such cases should not be left, in general, to the workman. If the waste is such that it can be reworked into other products, the job in question should be credited with the value of the saving. Waste which cannot be reworked, but which can be sold at a reduced price as scrap, is a general credit offsetting general expense. This is an important item in some industries, and the general consideration of savings thru careful segregation and collection of scrap is well worth considering in any industry.

7. *Reduction of labor costs.*—The reduction of labor costs involves a consideration of design, of quantity to be manufactured, of processes and equipment, and of the characteristics of the individual worker.

It is not enough that the design of a given piece of product will do the work that is required of it or will be satisfactory for the purpose for which it is intended. It should also be designed so that it can be produced in an economical manner and, if possible, with the equipment at hand. A good designer will have constantly in mind the methods that will be necessary to produce the part he is designing, and low costs in general must begin with the designer.

A careful consideration of any product will often reveal changes of form that will in no way lower the effectiveness of the product but which will make considerable difference in the labor cost. In fact, no product that is to be produced in large quantities

should be approved for production until passed upon by the manufacturing superintendent, or some one in his department who fully understands the processes necessary for the production of the work under consideration. This procedure is followed in many enterprises where mass production on a large scale is in operation.

8. *Relation between quantity and equipment.*—It is explained in Chapter II of the volume on "Plant Management" that the unit cost of production can be reduced if the quantity is sufficient to warrant the making of labor-saving appliances. An increase in the quantity that is to be made will often, therefore, make possible the construction of new or better tools, with a consequent reduction in unit cost. It is better economy often to manufacture a large quantity at one time and carry the surplus in stores than to have the product coming thru the shop in small lots as needed. Many shops lose much money thru too frequent setting up and taking down of manufacturing equipment. This point is more fully discussed in Chapter XVIII. The consideration of the methods and tools to be employed in producing a given part is one of the most important matters connected with any productive industry, and great labor-saving possibilities can often be realized by a committee discussion of this point.

It should be remembered in making investigations of this kind that special tools should not, usually, be considered as assets but should be charged to the cost

of production of the apparatus for which they have been made. The gain in unit cost must, therefore, be weighed against the first cost of the tools and the interest on the same, due regard being had to the maximum quantity that can be produced before the tools are worn out, and the probability of the tools becoming obsolete before that time. See also Section 6, Chapter VIII.

9. *Current ideas of expense.*—It will be clear from the preceding chapters that expense cannot be studied, like labor and material, with reference to particular jobs. Its origin and its method of operation are much more obscure and its usefulness or uselessness much more difficult to visualize. In approaching the study of expense reduction, therefore, it may be well to consider briefly certain of its characteristics. To most executives expense is something essentially baneful, something to be gotten rid of if possible, and yet there is no doubt but that blind cutting of expense may be a harmful proceeding. In a similar manner most executives will resist strenuously any attempt to add to current expense. This attitude often stands in the way of progressive methods. One reason for this attitude, probably, is the manner in which many expense items are incurred. Some foreman or clerk or other executive simply "wants" more help or additional supplies and these are granted largely because of fear of handicapping production, tho the executive may have serious doubts of the actual need of increasing the expense. Intelligent investigation of expense

with a view to determining its actual bearing on production is somewhat rare.

10. *True nature of expense.*—As a matter of fact, expense is an inherent characteristic of modern industry and springs directly from the use of division of labor. It does not appear to any marked extent in primitive industry, but has grown to great importance in connection with modern tools and modern specialization. Without it no intelligent direction of effort could exist and the economic gains that result from employing men according to their capabilities would be largely lost. It is a tool which, in the hands of a skillful executive, may be wonderfully effective, and in the hands of one less skillful it may work financial disaster.

Expense is not, therefore, of itself, an indication of inefficiency but, to the contrary, the absence of expense may be a mark of poor management as indicating that high-priced men may be doing work that can be done by lower-priced helpers. Or it may be that processes are being performed by high-priced men that can be done in a different manner which, tho involving an increase of the expense items, would reduce unit costs, thus accomplishing the desired result. Many of the gains claimed for advanced methods of management depend upon this very principle for their effectiveness. All of the so-called management systems that rest upon the work of F. W. Taylor involve an increase of expense in order to secure lower unit costs.

11. *The practical aspect of expense.*—While these theoretical considerations are true in the abstract, the experienced manager knows that for any given set of manufacturing conditions expense tends to increase without any decrease in unit costs, and he knows that the expense accounts if not watched with jealous care would soon devour his profits. It is this knowledge that makes most managers suspicious of any increase in expense even to the extent, sometimes, as has been noted, of standing in the way of what would be a decided gain financially. And it is this knowledge that makes the manager much more interested in expense reduction than in any plan which tends to add to this troublesome element. Having in mind, however, all of the considerations that have just been discussed it will appear that intelligent expense reduction will involve

(a) Analysis of the sources of expense

(b) Investigation of the need and usefulness of expense

(c) The setting of limits to prevent undue increase of expense.

12. *Analysis of the sources of expense.*—The sources of expense have been quite fully explained in Chapters VII and VIII, and in Section 7 of Chapter VII it has been shown how all expense items can be collected by classes for the purpose of allocating them in the costs and for the purpose of comparing the totals of any period with those of other periods. These classified accounts themselves afford an excel-

lent opportunity for the study of costs from month to month with a view of preventing their growth. But for a systematic study of any one of these expense factors a special expense report giving in detail the sources of the expense to be studied is of greater value. Such an expense report covering the repairs in a factory is shown in Figure 21. It will be noted that it shows the repair expense both by classes and by departments and makes possible a detailed discussion with those interested in and responsible for each item.

13. *Investigation of the usefulness of expense.*—Once the specific sources of expense are known it is usually not a difficult matter to decide what expenses are beneficial in operation and what can be dispensed with. Here again a committee is of great value in deciding these matters which are often of a personal character. It should be remembered that a committee is impersonal and the chances of obtaining a wise decision as to what is valuable and what is useless in expense is much greater if left to a committee than if left in the hands of some individual, unless this individual has great insight into manufacturing problems and great executive ability.

It should be remembered also that while it may often be desirable to reduce expense there may be cases where such a reduction would be poor economy; in fact, a committee of this character should have constantly in mind the possibility of increasing efficiency by a judicious addition to expense in some places and the reduction of expense elsewhere.

EXPENSE ANALYSIS SHEET
REPAIRS

FORM B
YEAR 192–

ACCT. NO.	MATERIAL	MONTH OF APRIL	% OF PROD. LABOR	PERIOD TO DATE	MONTH OF MAY	% OF PROD. LABOR	PERIOD TO DATE
340	Machine parts	243.20					
341	Electric supplies	50.00					
342	Bar stock	6.42					
345	Belting	75.60					
346	Painters supplies	80.70					
347	Lumber	25.30					
348	Cement and brick	8.90					
349	Bolts, nails etc	10.70					
350	Miscellaneous	30.65					
	TOTAL REPAIR MAT.	531.47	4.27				
	LABOR						
24	Machinists	94.60					
27	Blacksmiths	10.24					
31	Carpenters	56.40					
34	Pipefitters	42.36					
37	Masons	10.60					
41	Painters	175.24					
43	Roofers	5.60					
45	Helpers	34.20					
	TOTAL REPAIR LABOR	429.24	3.44				
	TOTAL REPAIR COST	960.71	7.71				
	DISTRIBUTION BY DEPARTMENTS						
	DEPT. A	150.26	1.20				
	" B	275.30	2.21				
	" C	50.36	.40				
	" D	190.18	1.53				
	" E	45.70	.37				
	GENERAL	248.91	2.00				
	PRODUCTIVE LABOR	12,462.40					

FIGURE 21

Such an investigation of expense is intelligent as compared with arbitrary reduction in a blind way which may or may not obtain the results desired. Expense labor and material, supplies, repairs and other items of expense can be studied in this manner; and when it is considered that the expense may form one third or more of the cost of production, the need of an inquiry into its character, as intelligent as that which is applied to productive labor as a matter of course, should be self-evident.

14. *Limiting expense.*—Out of a carefully conducted investigation such as has been discussed should come standards of some kind which will serve as guides in keeping expense within definite limits. A very effective way of doing this is to set limits to the amount that each foreman may spend, in a given period of time, for each class of expense. Weekly or monthly statements should be issued from the cost department, in order that the attention of each official may be called periodically to the important question of how his budget stands. Much of the excess and variation in expense outlay is due to wastefulness, and it is surprising how quickly and effectively a budget system of this kind will remedy some of these wastes. Care should of course be taken that the budget is made up on correct data so that the work of production may not suffer. There is no economy in reducing the amount of oil to the point where bearings will suffer, or in reducing the amount of waste to be used to the point where machines will be untidy. In general.

however, a budget system will reveal an excessive use of expense material and labor, and will decidedly tend to check wastes and keep constant the relation between direct production and expense. The budget system is particularly effective in controlling the cost of expense supplies such as oil, waste, etc.

REVIEW

How should a manufacturer proceed to make an analysis of costs? Are "special reports" useful only in large quantity production?

What are the three points of attack for an analysis of cost with a view to reduction?

Why should the manufacturing superintendent pass upon all products which are to be produced in large quantities?

How may the reduction of "expense" increase the unit cost of production?

CHAPTER XVII

PREDETERMINATION OF COSTS—MATERIALS AND LABOR

1. *General.*—The functions of a cost system as a means of finding and recording costs, and also as a basis of managerial reports, have been discussed in the preceding sections. It remains to consider the third, and in some respects the most important, use of a cost system, namely, the predetermination and control of costs. It has been shown (see Section 5, Chapter XVI) how the cost of an article already produced may, perhaps, be reduced after studying the cost records; and it will be clear that, in general, accurate costs are a powerful means of studying cost reduction. If the costs show a certain record of performance, there would seem to be no reason why this performance cannot be repeated. Experience shows, however, that such is not always the case; in fact, it is a rare thing to have two lots of product come out at the same cost, even tho produced on the same machines and by the same men, unless special care is taken to insure this result (see Figure 19, page 244).

Yet the ability to predict performance and costs becomes more important daily as competition becomes more keen and strenuous. A few years ago it was not uncommon practice in the case of construction jobs, to trust to the honor and ability of a contractor,

and to reward him by paying him a percentage on costs. This form of contracting still survives to a limited extent, tho, generally, the contractor is called upon to state a definite maximum price. In most cases, however, the contractors, builders or merchants who are supplying goods are required to bid on the contract, the lowest bidder securing the work. From the grocer who sells a pound of sugar, to the man who bids on the construction of a canal or a battleship, a guarantee of maximum price is usually demanded before any business is transacted; and the bargain is not infrequently cemented by legal agreements and bonds, or other financial guarantees of faithful performance.

2. *Difficulties in predicting performance.*—When the contractor or merchant turns his eye inward on his enterprise, with a view to computing the price at which he can compete, he is, in general, confronted with the difficulties that have been discussed in the preceding chapters; and he must, in most cases, use extreme care in answering the momentous question: What is the cost of production? Material values he can usually compute with fair accuracy, but the case of labor is different. He finds that, in general, the *price* of labor per diem is fairly definitely fixed; but he may find no relation between that price and the *output* per diem, and the vexing problem of expense is ever with him. If the work is similar to some he has already done, good cost records will give him an adequate idea of his limitations, *provided he can insure a*

repetition of the performance. If the work is new in character, his costs may still be of great value, tho not based on this new class of work. The wide variation in almost any set of bids, even where the article is closely specified, is sufficient evidence of the difficulties that are to be met in predicting costs of production. For these reasons, and for others which have been discussed in the foregoing chapters, there is a rapidly growing demand on the part of managers for more accurate methods of cost prediction than are generally available.

3. *Estimating costs of production.*—Costs of production may be estimated for one of two purposes—namely, as a basis for bidding on work in the open market, or for fixing the price of production in the factory in advance of actual work. Estimating for the first purpose may here be considered, so far as cost finding bears upon this problem.

Estimating, of any kind, without the use of cost data can be little more than skillful guessing; unfortunately, much of the estimating that is done is of this character. Where large margins of safety can be had in the way of good profits, these simple methods may suffice; but wherever competition is a factor, successful bidding must rest on cost data of some kind. In many callings and industries, considerable data of this kind have been compiled, and may be found in books on estimating. It should be noted, however, that such data must be considered as representing average results only; a keen estimator will not

be satisfied with the accuracy of his predictions until he possesses data representing the best practice of his own enterprise. In general, therefore, each enterprise must collect its own data in accordance with the principles of cost finding which have been discussed in the preceding chapters.

These remarks hold true with even greater force in regard to the predetermination of costs for the purpose of setting labor values in the factory in advance of production. Without accurate cost data, it will be found that piece prices, or in fact any other form of prediction of labor values, are little better than guesses. Furthermore, unless these cost data have been obtained under standardized conditions, and unless they represent not only *what has been done,* but approximately at least, *the best that can be done,* the estimator cannot be sure that he has obtained accurate results.

4. *Distinction between actual costs and estimated costs.*—A careful distinction should be made, therefore, between predicted costs based on actual results, and certain other kinds of estimated costs. Cost estimates made in advance may be successfully realized in actual productive performances; but it should be remembered that actual costs must always be based on actual performance, and before estimated costs are used in any way they should be carefully compared with actual results. Some of the cost systems in common use, based on estimates only, and unchecked by actual records of results, must be considered, at best, entirely inadequate.

Thus, it is often customary to make an estimate of cost based upon estimated values of material, labor and expense, the estimates, for the most part, being based upon empirical information and personal judgment. If the productive operations involved are repeated, this estimate is checked or tested, in a rough way, and such corrections as may appear necessary are made, this procedure being repeated as often as may seem desirable. Clearly, such rough rule-of-thumb methods of predicting costs cannot be considered seriously when compared with methods based on any of the cost systems that have been discussed; yet the amount of estimating made in this manner is surprising.

Similar considerations apply to methods such as the list-percentage plan, so called, that is sometimes used in continuous-process industries with products such as soap, brick and cloth. Under this method, the costs of production of each brand or line of products are estimated by a percentage based upon the list prices. These list prices may not be the actual selling prices, but they will be proportional to them. The estimated costs are then checked by actual experience, and corrections are made where necessary. There may be instances where such crude methods will suffice, but it would seem that, if these estimated costs could be checked with accuracy by actual performance, it would be easier and more logical to accumulate accurate cost data on which more rational estimates could be made in the first place.

5. *Predetermination of material costs.*—The predetermination of material costs usually offers little difficulty. The art of designing all manner of manufactured products in advance of production, and of specifying the characteristics of material needed for the work, has been so highly developed that little need be left to chance, so far as direct material is concerned. Material can be weighed, counted, or otherwise measured in such a way as to make it possible to issue just what is needed to satisfy the requisitions (see Sections 4 and 5, Chapter V); and the fixing of the material values in advance of production, so far, at least, as direct material is concerned, can be made with some assurance of realizing the expectation. Losses due to waste and mistakes are unavoidable, but, as has been explained (see Section 13, Chapter V), these can be minimized, with proper care. The problem of predicting expense material is, of course, a part of the problem of predicting expense, or burden.

Obviously, also, if the material lists made for a given article are accurate, they need not be changed, so long as the article is made in that particular form. Such lists therefore, become standard and may serve as a definite basis of calculating material costs in advance.

6. *Control of labor costs, day rate.*—The control of labor costs is an entirely different matter, especially where the workers are on day rate. Even in the case of conscientious workmen there is a wide variation in the cost of production of similar articles at different

periods. This is often due as much to varying conditions of production as to any remissness on the part of the workers; but even with the best of workmen the rate of production will vary greatly where the day rate is assured and where, consequently, there is no special incentive for men to do their best. This is very well illustrated in Figure 19 (page 244), which shows a record of actual production in a well-managed shop. The variation in the productive time of various men and at different times is here clearly shown; and the difference in total cost per piece, shown in the last column, is not unusual. Evidently, the prediction of costs, under such circumstances, must be based on an average experience, or else a large allowance must be made for possible variation.

7. *Control of labor costs, piece rate.*—These considerations, no doubt, have had great influence in extending piece-rate methods. If the employer can persuade the workman to do a given piece of work at a definite labor price, the labor cost becomes definite and stable, and will remain so as long as the agreement holds good. The defects and difficulties of straight piecework methods have been touched upon in chapter XIII of the volume on "Plant Management." These disadvantages are real, and it is apparent that piecework is not universally applicable. There are many lines of manufacture, however, where this method in some form must be used, for best results. Thus, in a product consisting of many small parts, and in the manufacture of which the compe-

tition is keen, piece rates in some form are essential to stable costs that can be used with assurance in predicting future performances.

It would appear, at first sight, that there is little probability of such a variation in the cost per piece as appears in Figure 19, which is based on day-rate. If, however, different piece rates for the same piece of work are given to different operators, variations as wide as these may appear. They often occur where high-priced operators are put to work, in an emergency, on a class of work that is ordinarily performed by lower-priced men, for the higher-priced men insist upon and obtain a special higher rate.

8. *Labor-cost control under advanced wage systems.*—A careful consideration of the more advanced wage systems (see the Modern Business Text on "Plant Management") will show that these systems recognize the general principles just discussed. All of them, except the Taylor differential piece rate, recognize the value of the day rate as a basis of labor reward, but all of them lay stress, also, on the accomplishment of a definite amount of work before extra reward, or bonus, is given. This definite amount is also the minimum amount of output which, in the opinion of the employer, the workman should produce, tho, if he produces more, he is rewarded accordingly. All of these advanced methods of labor reward, therefore, aim to secure a definite amount of product for a definite amount of pay, and hence embody an essential principle of piece-work.

If the workman can be induced to produce to his utmost capacity on normal day pay the cost per piece will be the lowest that the employer can obtain. It is difficult, however, to induce workmen to so produce under day pay. If the worker exceeds the minimum production and earns a bonus his wages are increased and the price of the product per piece is decreased, both of which are very desirable. Obviously, however, if the minimum is so set that the worker can greatly exceed it and thus earn large bonuses, the labor cost may vary almost as widely as under day pay. This criticism is sometimes made of the Halsey premium plan, since under it the required minimum output is based on day-rate records, which may or may not show what a fair day's work should be.

The criticism of cost records based on day-work, piece-work and the Halsey premium plan, made by advocates of more advanced methods is, that while these records show *what has been done*, they fail utterly to show *what can be done*. In their efforts to establish a more stable relation between labor reward and labor cost, these advocates have introduced methods that promise to have an influence on costs that will entitle them to special consideration. Only brief mention can be made here of these methods, and only such discussion of them will be given as pertains to costs and cost-finding.

9. *Time-study.*—It has long been a practice among progressive managers to try to control labor costs by making preliminary studies of the time required to

perform operations. Sometimes this is done by having skilled workmen, who are in the confidence of the employer, make preliminary trials of the job; in some cases this work has been done openly, either in the production department proper, or in special shop laboratories equipped for the purpose. It remained for Mr. F. W. Taylor to systematize and refine methods of observation, with a view to the general solution of the problem of determining how long a given piece of work should take.[1]

Under these more refined methods, the time required to perform each detail of a given operation is taken with a stop-watch, by trained observers, and carefully recorded. Observations are made of many repetitions of each detail operation, as performed by several competent operators, and the recorded "unit times" are used as a basis for establishing a *standard of performance* from which other similar performances may be predicted, either in whole or in part. Allowance must be made, of course, for fatigue and rest, and many data are already available on this point.

It will appear at once that there are limitations to this method, particularly when the number of pieces to be produced is small, but it is obvious that as a mode of approaching labor-cost control it is a great advance over old empirical methods. Without doubt, time-study is destined to occupy a prominent place

[1] Those who wish to study these methods in detail are referred to Mr. Taylor's monumental paper, "Shop Management," in the "Transactions of the American Society of Mechanical Engineers," Vol. 24.

in industrial management, where refined costs are a factor.

10. *Motion-study.*—It has long been recognized that the amount of work produced by a workman is greatly affected by the *convenience* of his surroundings and tools. Complex assembling operations are usually made the object of careful study so that everything may be conveniently arranged and, furthermore, so that the *sequence* of operations may be the most effective. For the most part, however, these attempts have been confined to the best examples of mass production. The work of Mr. Frank Gilbreth has called attention to the fact that great gains in production can be made by systematic *motion-study* in all lines of work. The most interesting feature of this idea is that it frankly questions the efficiency of the methods practiced even by the simpler trades, and it has been conclusively shown that the handicraft practices are often far from efficient. It has been proved that many unnecessary motions can be eliminated even in cases where it was supposed that the highest efficiency had already been reached; the result is a gain in production and a lessening of the fatigue.

Motion-study, therefore, in conjunction with time-study, makes it possible to predict with reasonable accuracy how a piece of work should be done, and how long it should normally take to do it. The limitations of motion study are important, however, and should be carefully studied before these methods are

applied. The human factor involved in the application of these methods is of the utmost importance and it should be carefully considered.

11. *Industrial data.*—The ability to predict costs will depend not only upon the information gathered by time-study and motion-study but also considerably upon the exact knowledge of industrial processes that the rate-setter possesses. Thus, in machine work it may be possible to predict how long it should take to set a piece of work in the machine and get the work started. The time it may take to do the given machine operation will depend, however, on the capacity of the machine and the efficiency of the cutting tool. Data of this kind are not available in most industries and must, in general, be obtained for the specific work in hand. The task of collecting these data may be difficult even in what may appear to be simple operations, as shown in Mr. F. W. Taylor's experimental work on the art of cutting metals where twelve variable factors were found. It should be carefully noted that the skilled workman cannot usually give an accurate statement of the most efficient means of accomplishing his task. This is because of the complexity of even simple industrial processes, and because most workmen do their work as they were taught by older men to do it, with little or no thought, often, as to really efficient methods. Some progress is being made in collecting industrial data in many lines of work, and in the near future, no doubt, the information gained from such data will prove of the great-

est benefit in the solution of difficult industrial problems.

12. *Standard performances.*—If, then, the manager possesses information such as has been described in the three preceding sections, he will be able to predict with some degree of certainty the best way of doing work, and the time it should take to do it. Figure 22 (page 280) illustrates an instruction card, so called, showing a case where this has been done. It will be noted that the sequence of the several operations is prescribed; the number of the proper tool is given, where necessary; and the depth of the cut, the feed, and the speed at which the tool is to be driven are also stated. The time that each operation should take is given, and also the total time for the lot, including the time for changing the machine for another job. An allowance of 10 per cent is made, as a margin of safety. The total predicted time is recorded in such a way that it can be compared with the time actually required, which is also noted on the card.

If an instruction card, illustrated in Figure 22, is to be taken as a standard of performance, every surrounding condition must be carefully standardized, or else it will be impossible to realize the prediction in actual practice. The problems of standardizing industrial processes lie outside the limits of this book; for a fuller discussion of modern planning methods, the reader is referred to the Modern Business Text on "Plant Management."

13. *Limitations and difficulties.*—Evidently, there

EUREKA MFG. CO. No. 310

INSTRUCTION CARD

Order No.	Drawing No.	Part No.	No. of Pieces	Material	Mo.	Day	Year
2769	346	2A	20	WI	6	15	192–

Workman's Name	Machine	Speed Boss
Thomas Murphy	Lathe 70	Wm Russell

	Instructions	Tool	Cut	Feed	Speed	Piece Time		Lot Time	
1	Preparation							15	00
2	Locating and drilling centers							20	00
3	Facing ends	F 3				8	30		
4	Roughing cut large dia	L 6	125	.06	P3	20	00		
5	Roughing cut small dia	L 6	125	.06	P3	10	30		
6	Change tool	L6					25		
7	Change speed and feed						.15		
8	Second cut large dia	L5	.03	.15	R2	12	00		
9	Second cut small dia	L5	03	.15	R2	6	00		
10	Change tool	R3							
11	Chamfer corners	R3				2	00		
12	Stop machine and								
13	change work						25		
14	Clean machine and								
15	change work order							11	00
16	Add 10% to piece time					5	93		
17									
18									
19									
20									
	Totals for one piece					65	18	46	00

Total time for 20 pieces = 65.18X20+46 = 1349.6

Total time actually taken 1246

When machine cannot be run as specified report to R T Jones

Signature of foreman James Thomas

FIGURE 22. INSTRUCTION CARD

will be limitations to the refined methods of cost prediction just discussed. They cannot, for instance, be economically applied where the product is small in volume and of great variety. In fact, the same limitations that have already been noted regarding elaborate cost-finding methods apply to the planning of costs in advance or to the prearranging of any other part of administration where system is needed. There are limitations and difficulties also in operating these methods from the standpoint of the human element involved.

How far it may be economically possible to introduce these methods that have been so widely discussed in connection with scientific management, as this movement has been called, cannot be discussed here. The general idea of predicting labor values will, however, become a permanent feature of industrial management, and progressive managers should give this phase of cost finding careful attention, especially where the volume of production is large, and competition keen.

14. *Connection with advanced wage system.*—The reasons for some features of the advanced wage systems that have been mentioned will now be clear. These new methods of rewarding labor have grown out of the effort to set a definite task for the worker. Thus the Gantt bonus method, which may be taken as typical, sets a definite task which must be accomplished before a bonus, or extra reward, is given. For any production less than the task, only day rate is

given. The object of this bonus is evident. The task, set on the basis of time-study and the standardization of all surrounding conditions, is large, and the worker can generally accomplish it only by carefully following directions and detail instructions. The only incentive that will induce him to make this added effort is added compensation. If the preliminary studies are accurate, it will appear that the task can be so set as to demand the workman's utmost effort, and it is this aspect of these new methods that has received the strongest condemnation. Aside, however, from the possibility and advisability of installing such wage systems, the influence of these methods on cost prediction should be carefully noted. All ways and means that enable the manager to control labor costs, or to remove in any way the uncertainty that usually surrounds the cost of production, will be carefully studied in the near future.

REVIEW

What distinction do you make between estimated costs and actual costs?

What are predetermined costs, and how are they obtained?

What are the principal difficulties encountered in predicting performance?

How are labor costs controlled under the different systems of wage payment?

How would you undertake time and motion-studies?

What are the essential features of an instruction card?

CHAPTER XVIII

PREDETERMINATION OF COSTS—EXPENSE

1. *Preparation costs.*—All work is divisible into two stages, namely, preparation and actual operation. Thus it will be noted that in Figure 22 (page 280), the time for preparation, and the time for changing the machine at the end of the operation, are planned as separate items. The importance of the time required to get ready to do a piece of work is often overlooked, in spite of the fact that it may have a great effect upon the cost per piece; no one thing shows more clearly the desirability of making parts in quantities.

Referring to Figure 23 (page 284), suppose that it takes four hours to prepare for a piece of work. This constant value, no matter how many pieces are made, is indicated by the vertical ordinates of the line AB. Suppose, further, that it takes one hour to do the operation on each piece, after preparation has been made. Then the number of hours consumed in actual operation on any given number of pieces is indicated by the vertical ordinates between the line AB and the line AC; and the total time required to prepare for, and produce, any given number of pieces will be indicated by the ordinates between OM and AC. Thus, it will require fifty-four hours to prepare for and pro-

duce fifty pieces; twenty-nine hours to prepare for and produce twenty-five pieces, and so on.

The unit time, or time per piece, is found by dividing this total time, or the sum of the time for prepara-

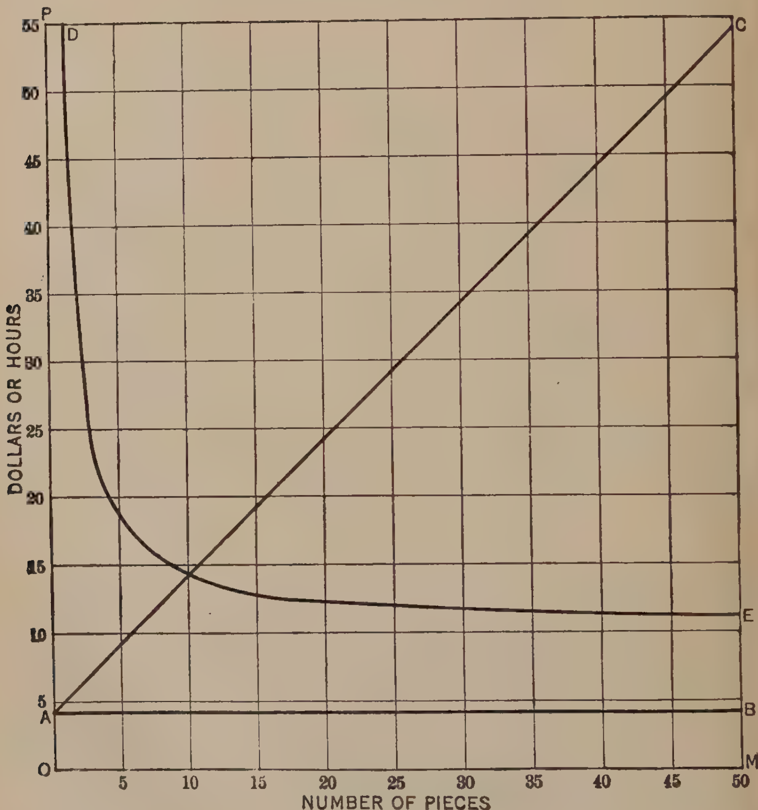


FIGURE 23

tion and the time of operation, by the number produced. For one piece, then, the unit time is $1 + 4 \div 1 = 5$ hours; for two pieces, it is $2 + 4 \div 2 = 3$

hours; for five pieces, it is $4 + 5 \div 5 = 1.8$ hours; and for fifty pieces, it is $4 + 50 \div 50 = 1.08$ hours. The curve DE is the curve of unit times, its vertical ordinates being one-tenth the value of those used for AC. The rapid fall on the first part of this curve should be carefully noted. The greatest fall in unit values occurs when two pieces are made instead of one, a constantly decreasing gain per piece being obtained as the number increases, till, after thirty or forty pieces, the preparation time becomes almost negligible, so far as the unit cost is concerned. This principle, which holds good whether the preparation is measured in time or dollars, is, in fact, the basic principle of mass production; and the larger the number of units to be made, the more the time and money that can be economically expended on preparation and planning of all kinds. Data bearing on preparation are therefore very important in cost prediction.

2. *Application to special tools.*—The general principle discussed in the preceding section applies also to all special tools, such as jigs, fixtures, etc., and, in fact, to all preparatory work such as making drawings and patterns, that may be chargeable to any particular piece of work. Suppose, for instance, that the manufacturing expense is equal to the direct labor, and that the labor cost on a given piece of work is two dollars. Then the cost of production (aside from the material values) will be four dollars. Suppose, further, that by making a special tool worth $60 the labor cost can be reduced to fifty cents, and the productive

cost, not including cost of material, is consequently reduced to one dollar. Since the gain in productive cost is three dollars per piece, twenty pieces must be made before the tool will be paid for. The unit cost when just twenty pieces are made will be $\frac{\$60 + \$20}{20} =$ $4, or the same as when no special tool is used. If more than twenty pieces are made, the unit cost will be decreased; and if less than twenty pieces are produced the unit cost will be more than $4, and the special tool will be the cause of a loss. Thus, if 100 pieces are made, the unit cost will be $\frac{\$60 + \$100}{100} = \$1.60$; while if only four pieces are made the unit cost will be $\frac{\$60 + \$4}{4} = \$16$.

If sixty pieces are made, the cost of the tool equals the cost of the labor and the expense. Up to this number of pieces, the controlling factor in the unit cost is the cost of the tool; but beyond this number, the controlling factor is the labor cost, and the cost of the tool soon becomes a small part of the unit cost. Thus, it has been shown that when 100 pieces are made, only 60 cents is added to cover the cost of the tool. This rather striking example emphasizes that intelligent cost prediction, where the use of labor-saving tools is involved, must take account of these factors. It has already been shown that in the case of all equipment the interest on the investment must also be taken into account if accuracy in this matter is to be obtained.

3. *Graphic cost data.*—The values shown in Figure 23 (page 284), have been assumed at random, but they are probable values. The usefulness of expressing standardized cost data in this form will be evident when costs are to be predicted. If laid off on sheets of large size such graphs will save much computation where varying numbers of pieces are to be produced from time to time; they will also serve to indicate quickly the minimum number of pieces that can be economically produced.

The principle involved is also of very great importance to the small manufacturer who is making parts which require considerable preparation. The decided saving in unit cost that follows from making even a small number of parts at one time, where preparation is a factor, is not, in general, well understood; yet careful planning in advance would often make such savings possible.

4. *Predicting expense.*—It will appear from the discussion in Chapter VII that the methods of cost control and cost prediction, as applied to material and labor values, as previously discussed, are not applicable to expense, or burden. It is not possible, under any known system, to predetermine with accuracy each item of expense material and labor that will be needed for a given piece of production, since, as has been explained, many of these items are not directly connected with the given piece; in fact the connection may be very remote.

The totals of these expenditures can, however, be

closely controlled by properly arranged cost reports as has been explained in Chapter XVII of the volume on "Plant Management" of the Modern Business Text. The discussion in Chapter XVI of this volume has shown how expense may be studied in detail and limitations set to its growth by means of a budget system. If the budget system can be enforced it will be clear that the probable expense both by totals and by departments will be fairly well known. It should be carefully noted that a cost system may distribute burden satisfactorily, after it has been incurred, by using data based on past performances, correcting the rates from time to time so as to provide for variation, but a budget system which is to control expense in advance in an intelligent manner must have its totals set with some definite relation to the volume of business transacted. Care must be used also that a balanced budget is provided so that all departments are equally well cared for in matters of expense. The productive capacity of a plant is often measured by the efficiency of any department or even of some machine. These relations are often difficult to establish and maintain.

Since all the methods of distributing expense establish a relation between expense and some feature of material or labor, a close approximation of the expense necessary for a given piece of production can usually be made when this basic factor is known. This relation can be used with some assurance if expense totals are controlled in such a way as has been indi-

cated. But this approximation cannot be compared in accuracy with those methods of predetermining labor values that have been treated up to this point.

5. *Conclusions.*—The treatment of the subject up to this point will have made it clear that no one method of cost finding can be laid down that will answer the requirements of every situation. Each case must be studied independently and a system selected that will be applicable to the problem at hand. The discussion in the previous chapters is based, for the most part, on the problem of cost finding in manufacturing plants, for the reason that it is in these plants that the problem is most complex and most perplexing. The general principles discussed hold true, however, for all cost-finding methods, tho the exact manner of their application necessarily differs with circumstances.

It is of prime importance, therefore, that the executive, in installing a cost-finding system, or in operating one already installed, should have a clear idea of just what results are desirable. A cost-finding system should be planned in advance as much as, if not more than, any other part of the factory system. It should obtain just the results wished, and it should not gather a lot of useless data. Such a system can fail because of too much detail, as easily as it can fail because of lack of results. It is of importance, also, that the results obtained be made use of, for cost data which are not used represent wasted money. It requires a man

with knowledge, intelligence and judgment, well informed in the details of the business, to plan and operate successfully a cost-finding system, if the problem is at all complex.

The introduction of a cost-finding system is often difficult. This is true partly because the human element enters largely into the success or failure of nearly all so-called "systems." Workmen are not generally interested in cost-finding methods, foremen are often antagonistic, and even the superintendent may be at least apathetic. It often takes considerable time and persistence to put a cost-finding system into successful operation; and it nearly always requires the firm support of the managing executive to maintain it. When, however, the executive has once developed a cost-finding system which presents to him the complete costs of his units of production; which shows him in intelligent detail where the money has gone, whether for direct or indirect production; which shows him the relative values of different methods; and which enables him to check inefficiency in machine, process or employe—when the executive has perfected such a system, he has obtained the best possible safeguard against failure, and a guide to future operations which must be used to be appreciated. The need of a cost-finding system of some sort is so basic that it is marvelous indeed that any man should think of operating a factory without one; and, without doubt, wherever competition is a factor, a cost-finding

system will be the corner-stone of the factory of the future.

REVIEW

What are preparation costs?

Of what advantage is the graphic method for the presentation of cost data?

What data may be had for use as a basis in predetermining expense?

What difficulties are usually experienced in introducing a cost system? How would you plan to overcome them?

CHAPTER XIX

APPLICATION OF COST-FINDING METHODS

1. *Principles of cost finding universally applicable.*—The discussion in the preceding chapters has centered largely around factory operations and manufacturing processes, and most of the illustrations that have been used have been taken from factory work of some kind. This is a natural proceeding since cost-finding has grown up for the most part in factory work, and it is here that the most complex cost-finding problems are to be found. As has been noted in Section 11 of Chapter III, however, the principles that have been developed are applicable with proper modification to a wide range of activities, commercial as well as industrial. There are many enterprises in operation today that are still depending on some system of general bookkeeping and which are facing financial disaster because this method tells them little or nothing about individual costs. It may be instructive, therefore, to discuss briefly the applicability of the principles that have been developed to various kinds of industry.

2. *Classification of industry.*—An intelligent selection of a cost system requires a clear understanding

of a few fundamental conceptions that have been discussed in the preceding chapters. It will have been made clear (see Chapter IV) that there are two classes of industry that are clear cut in their characteristics and for which there is little trouble in selecting the salient features of a cost system that will be satisfactory.

The first of these is the type of industry in which each article or lot of articles is distinct from other products and can be numbered or named in such a distinctive way that all labor and material expended upon them can be accurately recorded against their distinguishing number or name by means of time cards and bills of material. Expense can be allocated by some one of the methods that have been described. A boiler works making boilers to order is a good example of enterprises of this kind.

The second clearly defined type of industry includes those in which a single product is made, the material flowing in a constant stream thru the machines and processes. All that is necessary in order to find costs in such cases is to divide the total number of units produced into the total cost of production for a given time. Cement plants and simple ore reduction mills are good examples of this type of industry.

The majority of industries, however, fall in between these two extreme types. They may approximate one or the other of these types, or they may possess elements of both. In some cases the mixture of intermittent and continuous processes is so inti-

mate as to make accurate cost finding difficult if not impossible.

3. *Foundry costs.*—There are many industries where the methods that have been described are often held to be inapplicable because of supposed peculiarities in the work. Managers will claim that their work and problems are "different" and it is difficult to interest them in modern methods. In most cases this claim is imaginary and comes, often, from having inherited certain old ideas and methods. As a matter of fact most of them can use the methods that have been described, with little modification. Foundry costs are a good example of this. At first sight the work may appear to differ greatly from other forms of factory work, but closer inspection will show that this difference is not very great.

4. *Foundry stores system.*—There is nothing in the operation of a foundry, for instance, that prevents the operation of a good stores system which is the foundation of costs. There is no reason why all material and supplies for a foundry cannot be checked out as are similar items for a machine shop, and the idea of a continuous inventory which makes possible an accurate monthly statement applies here as elsewhere.

It will be argued by many that nails, gaggers and such small matters cannot be handled in this way. There would seem to be no reason why foundry foremen cannot draw such supplies on requisition, and such procedure makes possible departmental expense

charges which, in turn, may be used as a check upon wasteful methods.

5. *Elements of foundry costs.*—Foundry work divides itself naturally into four departments, namely, melting, molding, coremaking, and cleaning. The elements of cost, therefore, are the cost of metal at the spout of the cupola, the cost of molding, the cost of cores, if any are used, the cost of cleaning, and the general expense or burden incident to the operation of these departments and such departments as the store system and stock room if castings are carried in stock. Each department will have its own peculiar expense items and each department should be charged with these items so that departmental burden can be readily computed for any piece of work. This procedure is necessary, also, to check up the cost of operating each department, and this is desirable under almost any circumstances.

6. *Cost of metal.*—If all labor, material and expense incident to melting the metal are collected into one account it would appear to be easy to compute the cost of the melted metal by weight. And this would be true if all castings were good and sound. There is always a certain amount of bad castings, however, and this amount must be considered in the costs. There is also a considerable amount of metal poured in the form of risers and runners that must be returned to the cupola and remelted. The cupola labor, expense, and fuel used in melting metal from defective castings and runners is, of course, lost unless

recovered from sales of other castings. The cost of melting, therefore, should be distributed on the amount of good castings produced. A simple way of providing for this difficulty is to charge off all melting room charges against the total weight of good castings produced and debit the melting room with the material value of all metal returned in the form of bad castings, runners, etc.

In some foundries the actual material cost of the melted metal is kept separate from the labor and expense of the melting department. It is thus possible to fix the material cost per pound for all castings, good or bad.

7. *Distribution of departmental expense.*—The expense of the core-making department can usually be distributed as a percentage on productive labor without great error. The method of distributing the expense of the molding departments will depend upon the class of work performed. If the work is of the same general character and fairly uniform in size, the much-used practice of distributing all molding costs on the basis of the weight of the castings has some justification and provides a simple method. Where the product is diverse in size and character, however, distribution of expense to production orders as a percentage on direct labor will give more accurate results.

If the work of the foundry varies greatly in size and character all the arguments in favor of departmentization set forth in Section 3 of Chapter XIV

apply fully. And in very large work there would seem to be no reason why the method of production centers cannot be used with success. The discussion in Section 2 of Chapter VIII concerning defective material and spoiled work applies fully to the disposition of the labor and expense involved in bad work and defective castings. The material values of defective castings have been discussed.

Similar remarks apply to the cleaning department. If the work is all small and similar in character the expense of cleaning can be charged off on the basis of weight, but where the product is diverse in size and where a single casting may require several hours to chip and clean, it is much more accurate to make direct charges against each production order, distributing the expense of the department, including the cost of supervision, as a percentage on the labor employed.

8. *General foundry expense.*—If all expense items can be equitably divided among the departments the total expense would be discharged thru the departmental expense charges. It is not always desirable to do this, however, and usually there will be certain general expense charges such as the cost of unloading, handling, and transporting material, certain clerical labor and other items incident to the general conduct of the business which rise and fall in amount more nearly in proportion to the weight of product than to the direct labor employed. If such expenses exist, therefore, they can be discharged as a percentage on

weight. These general expenses are to be distinguished from commercial and selling expenses which are distributable on the basis of shop cost. See Section 1, Chapter XIV.

Summary.—It would appear from the foregoing that there is nothing inherent in foundry work that in any way renders inapplicable the general principles of cost finding that have been discussed in the preceding chapters. Foundries, like all industrial and commercial activities, vary in size and in character of product, but not nearly so much as do machine building establishments; and foundry cost finding, on the whole, is simpler than in these latter enterprises.

9. *Intermittent process industries.*—An important group of industries in which cost finding methods have not as yet been very fully developed includes those in which the product is made in large lots that vary somewhat in character and quality but yet make use of the same or similar processes. Enterprises making food preparations, candy factories, textile industries and lumber mills are good examples of this type of enterprise. Here again the claim is frequently made that the peculiarities of these industries make the methods that have been advocated in the preceding chapters inapplicable, and many manufacturers in these industries prefer to retain their old bookkeeping methods which they have inherited from the early days of the industry. It should be carefully noted in this respect that, while these ordinary bookkeeping methods will show the owner the totals of his

business and will indicate whether he is or is not making money, they will not show him what lines of product are paying and what are not.

In reality these enterprises differ in no way from any other form of enterprise where the costs of individual items are not required and where the material passes thru several processes in lots or "batches," absorbing in each process both labor and material. Plating, dipping and baking processes in machine-building industries are of the same general character, and the discussion in Section 5 of Chapter XIII bearing on these processes furnishes the solution to cost finding in industries that are made up almost entirely of analogous methods. The construction of an adequate cost-finding system for enterprises of this kind will be greatly simplified by keeping certain fundamental principles clearly in mind. First it should be remembered that all productive costs are made up of material, labor and expense. It follows, therefore, that a cost system should allocate accurately the material and labor which go into each lot of product. Secondly it should be borne in mind that careful departmentization by processes is always a great aid to the intelligent allocation of expense in such cases.

10. *Cost of candy manufacture.*—In candy making, for instance, there is no reason why all material cannot be drawn on requisition and an accurate account kept of all material components of the product, particularly as candy is made in fairly exact proportions. The practice of allowing foremen to draw

what they wish and simply requiring them to report what they have drawn and what they have produced, puts no check on wasteful practices and is contrary to the fundamentals of cost finding. (See Chapter V.) A good stores system is not only possible in such work, but absolutely essential to economical management and good costs.

Such factories should be carefully divided into departments by processes as for instance purchasing, stores, cocoa grinding, fondant, coating, hard candy, packing and selling, etc. Each of these should be charged with its own direct and indirect labor and other expenses. If the factory is small, all the factory expense can be so allocated and charged off by departments. If, however, the factory is very large and there is much supervision and handling it may be wise to collect certain general expenses and discharge them as has been suggested in connection with general foundry expense in Section 8 of this chapter. Departmental expenses may be discharged in two ways. If the expenses consist largely of indirect labor and fixed charges they may be discharged as a percentage on direct labor. In such work as dipping it may be necessary to consider the coating as an expense material and charge it off against the weight of the product coated (see also Section 8 of Chapter XIII). The factory cost would, therefore, be made up of the material cost, the direct labor, the departmental expenses, the general factory expense, if such is necessary, and the cost of packing. The cost of

managing the business and selling expense can be distributed on the basis of factory cost as explained in Chapter XIV.

11. *Fluctuations in base prices.*—In industries such as candy making, the market price of the materials fluctuates from week to week or even from day to day, and this must be taken account of in fixing selling prices. These fluctuations may be so great and so frequent that the method of averaging explained in Section 9 of Chapter V may not suffice. If it is desired to keep the sales price in harmony with the market prices, the cost of a given amount of each product can be worked out on the basis of certain base charges for material. Since the proportions of the ingredients in each kind of candy are known, the sales price can be easily corrected to approximate the changes in the market prices of supplies.

12. *Other industries.*—Many other illustrations could be cited to show the general application of cost-finding methods tho superficially these methods may appear to be quite different. The particular methods that may apply to a tannery will not apply to a shoe factory, nor will the blanks and forms that apply to a textile mill be applicable to a paper mill. Each industry offers its own special cost-finding problems depending on the character of the processes involved, but the basic principles are comparatively few as has been already demonstrated. The problem of the cost accountant is to apply these basic principles in an intelligent manner so as to secure the required results

with a minimum expenditure of time and money. It should be noted furthermore that cost-finding methods may vary widely in the same industry. In one machine shop it may be desirable to secure the cost of each individual machine while in another the cost of groups of machines may suffice. Here again, however, the basic methods of cost finding will be the same tho varying in their application.

13. *Commercial costs.*—Another important field where cost-finding methods are slowly finding recognition is in the field of retail merchandising. In this field such accounts as are kept usually do not go beyond ordinary bookkeeping. The Federal Trade Commission, appreciating this weakness in our mercantile system, has issued a pamphlet setting forth a simple accounting system for retail merchants. In the preliminary statement of this pamphlet stress is laid upon two points—namely, the absolute necessity of the merchant knowing his expenses and the need of making as frequent a turnover of his money as possible.

Bookkeeping and accounting methods have been well developed for commercial enterprises, and it would seem at first sight as tho cost-finding methods would be of little benefit. It should be remembered again that the usual accounting systems show only what total gains or losses have been made, and if it is desired to know what lines pay and what do not pay cost-finding methods must be resorted to here

as elsewhere. In a small retail store, for instance, where many articles are sold, it is not possible, in general, to tell with accuracy just what lines pay best, since expense distribution must be by some averaging method. Even here care should be used in setting prices so as to cover the expense and provide a profit, and the reader should reread Sections 9 and 10 of Chapter III which deal with an important phase of this matter.

14. *Departmentization of retail stores.*—Even in small retail stores an effort should be made to segregate expense by activities if for no other reason than to check up variations in these factors. Figure 24, which is taken from the Government publication already referred to, shows a monthly statement of a retail business so arranged as to show all important items of expense by classes. The buying expense, the selling expense and the expense of delivery are shown separated from the general expenses of the business.

When a store grows large enough to have independent departments such as hats, shoes, gloves, etc., many of the cost-finding methods that have been discussed become pertinent. Each department should then be charged with its own labor and expense and such a share of the general expense as properly belongs to it. In fact the general theory of production centers applies here quite closely, and managers of department stores may gain much help by a careful

MONTHLY SUMMARY OF BUSINESS, 19—

	Net Sales			Buying expense		Selling expense			Delivery expense		General expense								
	Credit	Cash	Total	Salaries and Wages of Buying Force	Miscellaneous Buying Expense	Salaries and Wages of Sales Force	Advertising	Miscellaneous Selling Expense	Salaries and Wages of Delivery Force	Miscellaneous Delivery Expense	Management and Office Salaries	Office Supplies and Expense	Insurance on Stock and Store Equipment	Taxes on Stock and Store Equipment	Losses from Bad Debts	Miscellaneous General Expense	Rent	Total Expense	Per cent of Net Sales
Jan.	$3,356.31	$1,301.65	$4,657.96	$25.00	$14.00	$177.33	$30.00	$3.75	$102.67	$8.08	$269.00	$22.03	$1.61	$2.50	$33.56	$26.79	$71.25	$787.57	16.9
Feb.																			
Mar.																			
Apr.																			
May																			
June																			
July																			
Aug.																			
Sept.																			
Oct.																			
Nov.																			
Dec.																			
Total,																			
Per cent of Net Sales																			

FIGURE 24

study of these methods that have been so effective in other lines of work, for the averaging methods that are commonly used in commercial establishments for distributing expense are not fair to all concerned.

Thus heat, light, power, elevator service, insurance, rent, taxes, should be divided among the departments in proportion to the services rendered, and all general expense chargeable to the commercial department should be allocated as fairly as possible. Only by so doing is it possible to hold each department head responsible for results and to check up his results against the facilities that he has had at his disposal.

15. *Departmental costs.*—When a commercial establishment grows to large proportions the cost accounting of some of the departments themselves may be interesting and important. Thus the delivery department of a large store operating a large number of motor trucks offers a good field for good cost investigation and control. A careful record should be kept, in some detail, of the operating expenses of each truck and also of the service rendered. This provides a check not only upon the efficiency of the truck, but upon the efficiency of the driver. Progressive merchants who operate such large delivery departments require a daily report on each truck and a summarized monthly report as well. This procedure, it will be noted, is simply applying the principles of cost analysis that have been discussed in Chapter XVI.

REVIEW

Why should every business enterprise have an up-to-date cost-finding system?

What cost-finding system would you devise for use in a foundry?

Show how cost-finding methods may be applied to intermittent industries and even to retail establishments.

What general conclusions are the result of your study of this volume? Why do many cost systems fail?

NOTE: Numerous questions of business practice and procedure are discussed in detail in the Modern Business Reports. The current list will show those which are especially related to this volume. Among them may be mentioned

1. Inventories, Physical and Perpetual.
5. Cost Accounting Systems.
45. A Cost Accounting System for a Bank.
95. Construction Accounts.

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